CHEMICAL GROWTH REGULATION OF LANDSCAPE GROUNDCOVERS

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF
THE UNIVERSITY OF HAWAI'I
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN

HORTICULTURE

DECEMBER 1999

By

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We certify that we have read this thesis and that, in our opinion, it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Horticulture.

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ACKNOWLEDGMENTS

This is written with great appreciation to all who have supported me in completing this project. A sincere thank you to my committee members Dr. Richard Criley, Dr. Skip Bittenbender and Dr. Charles Murdoch for your guidance and support. A special thank you to my committee chair, Dr. David Hensley, for your hard work, encouragement, patience and humor and for all you have taught me about the world of landscaping. To Paul Murakami, Melissa Kellison, Julie Yogi and Cesar Ngoya, a genuine thank you for your assistance and friendship. To the crews at the Magoon Greenhouse facility and Waimanalo Research Station, sincere gratitude for all of your hard work. Thanks also to Jimmy Kuroiwa and Mahana Landscaping, Inc. for the use of Kapolei Golf Course.

A heartfelt thanks to my wonderful family and friends who have given me so much love and support. To my parents, all my love for your support and encouragement and for the opportunities you have made possible for me.

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LITERATURE REVIEW

INTRODUCTION

Ground covers are widely used in landscapes in Hawai'i for their aesthetic value and to provide erosion control in areas where quality turf cannot be grown. Many groundcovers, however, require a great deal of labor to control size, prevent invasion of other areas, and to maintain the quality of the planting. Some species require biweekly pruning in manicured landscapes. Maintenance labor to prune groundcovers increases expenses of landscape firms and clientele alike. Heavily pruned groundcover beds are unsightly for a period of time.

Chemical growth regulators have been used for a number of years, especially in the production of greenhouse and fruit crops. These first generation growth regulators, which have given inconsistent results in control of landscape species, caused discoloration or damage to plants, and could only be used on a limited number of species. Recently, second and third generation growth regulators have entered the market. These are less phytotoxic, provide greater control with lower rates, and are active on a wide range of species. These newer growth regulators are labeled for use on many bedding plants, some hedge species, and several trees.

USE OF CHEMICAL GROWTH REGULATORS ON ORNAMENTALS

There is a great deal of literature on the use of plant growth regulators in the ornamental horticulture industry, but little on their use on groundcovers. Several studies have shown that chemical growth regulators effectively suppress plant growth. Paclobutrazol and uniconazole have been used successfully on a number of common bedding plants such as begonia, impatiens, vinca and zinnia (Banko, et al.,1988) as well as on salvia, marigold and petunia (Barret, et al.,1992). Wang, et.al.(1992) found pothos to be more marketable when treated with uniconazole due to its more compact growth. Laiche (1988) found that both media drenches and foliar sprays of flurprimidol are effective in reducing the growth rate of *Ilex* and *Photinia* for over a year. Flurprimidol, uniconazole, and dikegulac also suppressed growth of pyracantha, ligustrum and euonymus, as well as reduced water stress (Norcini, 1991). Cimectacarb also caused growth suppression, but was more species dependent (Stamps, 1990). Wang, et.al. and Wample, et.al. found paclobutrazol to improve plant water status, possibly due to the decrease growth rate or a change in leaf morphology.

By decreasing the amount of plant growth, pruning and labor requirements are also reduced. When flurprimidol was used on maple and oak, biomass production was decreased by 75% and trim and chip time was decreased by 55% (Redding, et al., 1994). Johnson (1993) also found

dikegulac and cimectacarb to eliminate 3 mowings of tall fescue over a five week period without effecting the quality of the turf.

GROUNDCOVERS

In Hawai'i, groundcovers are used in residential and commercial landscapes in place of turf. Commonly planted groundcovers include Blue Daze (*Evolvulus glomeratus*), False Heather (*Cuphea hyssopifolia*) and Wedelia (*Wedelia trilobata*).

Blue Daze and False Heather are both small, shrubby plants that can grow to a heigth of 2'. They are grown for their clean foliage and blue flowers. When allowed to grow to their full size, they become scraggly and are better when trimmed to create a more dense appearance. Because both have fairly rapid growth rates, trimming needs to be done every 2 to 5 weeks, depending on growing conditions.

Wedelia is an aggressive, trailing groundcover with yellow daisy-type flowers. It is one of the most popular grown groundcovers in Hawai'i, due to its rapid ability to fill in large areas, stabilize soil and choke out weeds. It is also adapted to a wide variety of growing conditions. Because of its fast growth rate, it requires a great deal of trimming to keep it neat and contained.

GROWTH REGULATORS

Early uses of growth regulators involved using Type I growth regulators, which inhibit both growth and development by suppressing cell division and/or differentiation at the growing points (Schott and Walter, 1989). Growth regulators in this category include amidochlor, maleic hydrazide and mefluidide.

Type I growth regulators are widely used on fruit and vegetable crops and some turfgrass (Davis and Curry, 1991). Mainly, they are used to suppress suckering in bulb and root crops during storage and to inhibit seed head formation in grasses. They have been used little on ornamental plants due to the phytotoxic damage they cause at effective rates (Banko and Stefani, 1988). Damage includes foliar discoloration and distortion and terminal bud death.

More recent growth regulators act by blocking enzymes in the biosynthesis pathway of gibberellic acid (GA), therefore reducing cell elongation and resulting in reduced internode growth (Davis, et. al., 1988). These Type II growth retardants effectively control growth at lower rates than their predecessors and cause less phytotoxic damage at high rates. Although at higher rates, they will reduce cell division. Because they inhibit gibberellin synthesis, they are effective on a wide variety of plant species. They are absorbed by the leaves, stems and roots and are translocated only in the xylem. Type II growth regulators can be applied as either a foliar spray or soil drench, although drenching has been found to be more effective (Davis, et. al., 1988).

Examples of the gibberellin biosynthesis inhibitors include:

- "Onium" compounds
- Compounds with a nitrogen containing heterocyle
- Cyclohexanetriones (Rademacher, 1988)

Onium compounds act early in the gibberellin synthesis pathway by inhibiting the production of ent-kaurene (Graebe, 1987) (Fig. 1.1). Growth regulators in this group include chlormequat chloride (Cycocel®) and mepiquat chloride. Because onium compounds reduce shoot growth in a limited number of plant species, they are mainly used on cereals, cotton and a few ornamental plant species (Rademacher, 1988).

Compounds with a nitrogen containing heterocyle are the largest group of gibberellin biosynthesis inhibitors. They include the triazoles, pyrimidines and tetcyclacis (Graebe, 1987). These act by inhibiting the oxidative steps from ent-kaurene to ent-kaurenoic acid (Radermacher, 1988) (Fig. 1.1). Examples of triazoles are paclobutrazol (Bonzi®) and uniconazole (Sumagic®). The pyrimidines include ancymidol and flurprimidol (Cutless®) (Graebe, 1987).

The cyclohexanetriones are one of the newest growth regulators on the market. They inhibit later steps in the GA synthesis pathway (Rademacher, 1988) (Fig. 1.1). They include cimectacarb (Primo®), a turfgrass growth retardant.

Of the GA inhibitors, paclobutrazol and uniconazole seem to be two of the most used in the ornamental industry, mainly due to their effectiveness at low rates (Davis and Curry, 1991; Steffens, 1988). Their growth regulating effects are more persistent than some of the other retardants, resulting in fewer applications as well.

GA biosynthesis inhibitors have great potential for use in the landscape industry. By reducing growth of groundcovers planted in the landscape, cost savings would be seen in:

- Decreased trim time
- Decreased frequency of trimmings
- Decreased labor costs
- Decreased fuel and equipment costs
- Less greenwaste production

Plants would also be healthier due to reduced trimming as well as maintaining a neat, compact growth habit.

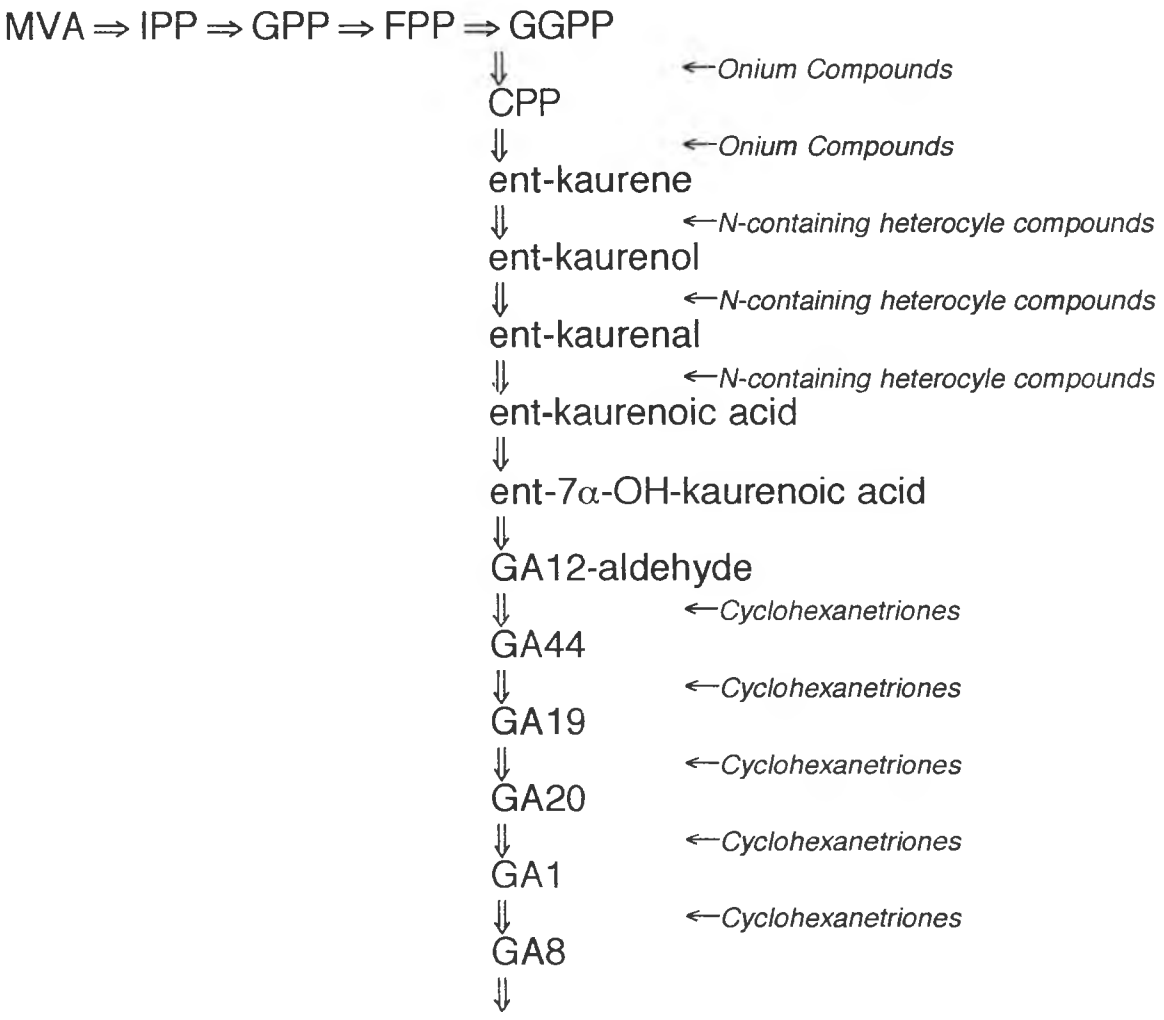


Figure 1.1: GA biosynthesis pathway and inhibition points by growth retardants (Rademacher, 1988)

CHAPTER II

PRELIMINARY RATE STUDIES ON VARIOUS CONTAINER GROWN GROUNDCOVERS

INTRODUCTION

Several studies have been conducted on the effects of growth regulators on ornamental plants, but little information is available on their use on landscape groundcovers. Synthetic growth regulators significantly reduced the growth of a number of woody landscape species in containers.

Flurprimidol at 500-600 ppm decreased the growth of *Abelia grandiflora*, *Cotoneaster dammeri*, *Gardenia jasminoides*, and *Nandina domestica* (Banko and Stefani, 1995). At low rates, flurprimidol decreased the growth of *Ilex crenata* and *Photinia* x *fraseri* for an entire growing season (Laiche, 1988). Dikegulac reduced growth of *Abelia grandiflora* at 1280 ppm and *Cotoneaster dammeri* and *Euonymus kiautschovicus* at 1600 ppm (Banko and Stefani, 1995). Spray and drench applications of uniconazole suppressed growth of *Berberis thunbergia* 'Atropurpurea', *Lagerstroemia indica* 'Natchez', and a number of *Rhododendron* species for 120 days (Warren, 1990). *Epipremnum aureum* was more marketable with uniconazole treatment (Wang, et.al., 1992). Paclobutrazol controlled the growth of *Codiaeum variegatum* 'Karen' and *Syngonium podophyllum* 'White Butterfly'. Growth of *Plectranthus australis* was also reduced, although branching was decreased by paclobutrazol, even at low rates (Wang and Blessington, 1990). Paclobutrazol and uniconazole have also reduced growth on a number of bedding plants such as *Begonia semperflorens*, *Catharanthus roseus*, *Impatiens sultani*, *Zinnia elegans,* (Banko, et. al., 1988)

salvia splendens, petunia hybrida and *tagetes erecta* (Barret, et. al., 1992). Cimectacarb also caused growth suppression, but the effect was species dependent (Stamps, 1990). On turfgrass, cimectacarb eliminated the need for three mowings of *Festuca arundinaceae* over a five week period without effecting the quality of the turf (Johnson, 1993).

Objectives of these studies were to:

1) evaluate materials for degree and length of growth regulation;

2) evaluate phytotoxicity;

3) determine effective rates for field studies; and to

4) compare application methods of several growth regulators.

MATERIALS AND METHODS

Study 1:

Two separate studies were conducted on a number of containerized groundcovers commonly grown in Hawai'i. Both studies were conducted at the University of Hawai'i Magoon Greenhouse facilities under 35% shade. Rooted cuttings of *Myoporum* spp. 'South Coast', *Myoporum* spp. 'Davis' and *Evolvulus glomeratus* (Blue Daze) were planted in one-quart pots, one plant to a pot. The media for this and subsequent studies consisted of 2:2:1 peat : perlite : soil by volume. The media was amended with 5.1kg/m of 18-6-12 (N-P-K) (Osmocote^{TM}), 1kg/m^3 trace elements (Micromax^{TM}), 3 kg/m^3 of dolomitic limestone, and 0.6 kg/m^3 of 0-46-0 (treble super phosphate). Treatments were arranged in randomized complete blocks with five replications. All plants were

cut to 15 cm on October 29, 1993 and treated with growth regulators on November 18, 1993.

Treatments consisted of an untreated control and applications at label recommendations (low) and two times label rates (high) of various growth regulators (Table 2.1). Growth regulators were applied as a drench with 20ml of water per pot. Height was measured every two weeks for twelve weeks. Irrigation was applied daily through overhead sprinklers. Plants were fertilized periodically with a topdress of 18N-6P-12K (Osmocote^{TM}). Data was analyzed using an analysis of variance and Tukey HSD to compare individual treatment means (Snedecor and Cochran, 1980).

Table 2.1. Growth regulator application rates for study 1 in amount of active ingredient per plant. Applied as a drench with 20ml of water.

	APPLICATION RATE	
MATERIAL	**LOW** (label rate)	**HIGH** (2X label rate)
Flurprimidol 50W	10 mg	20 mg
Paclobutrazol SC	45 mg	90 mg
Uniconazole 500	0.025 mg	0.05 mg

Study 2:

Growth regulators were applied as a spray or drench on January 25, 1994 (Tables 2.2,3). Spray applications were with 200 ml of water per $1m^2$. Drench applications were made with 100ml of water to each pot. Controls were not treated.

Plants were arranged in randomized complete blocks and replications varied with species (4-5). Data was analyzed using an analysis of variance and Tukey HSD (Snedecor and Cochran, 1980).

Cuphea hyssopifolia and *Evolvulus glomeratus*: Two varieties of *C. hyssopifolia* were treated: one with red stems; and one with green stems. Rooted cuttings were grown in one-liter pots with 4 to 5 plants per container. Plants were cut to 10cm on January 29, 1994 for uniformity. Treatments were replicated four times with each pot as one experimental unit. Height was measured every two weeks for fourteen weeks after treatment.

Liriope muscari 'Variegata': Rooted cuttings were grown in one-liter pots with 4 - 5 plants per pot. They were cut to 10 cm on February 19, 1994 for uniformity. Treatments were replicated five times, one pot being an experimental unit. Height was measured every two weeks for fourteen weeks after treatment.

Wedelia trilobata: Rooted cuttings were grown in 3.8 liter pots, with one plant to a pot. Each pot was one experimental unit. Treatments were replicated five times. Plants were trimmed to 10cm on January 29, 1994 for uniformity. Growth was measured every two weeks for twelve weeks. Plants were again cut to 15cm on April 19, 1994. New growth was harvested and weighed after oven drying for 36 hours. On June 10, 1994 plants were cut to the soil line and dry weights were taken again.

Table 2.2. Spray treatments for study 2. Rates are in of active ingredient m^{-2}.

	SPRAY										
MATERIAL		CIMECTACARB		DIKEGULAC		FLURPRIMIDOL		PACLOBUTRAZOL		UNICONAZOLE	
	Ctrl	Low	High	Low	High	Low	High	Low	High	Low	High
RATE		1.4ml	2.8ml	112.2mg	336.5mg	170mg	510mg	37.3mg	111.8mg	2.5mg	49mg
Cuphea hyssopifolia green stem	X			X	X	X	X			X	X
Cuphea hyssopifolia red stem	X			X	X	X	X	X	X		
Evoivulus glomeratus	X			X	X	X	X	X	X	X	X
Liriope muscari 'Variegata'	X	X	X	X	X	X	X				
Wedelia trilobata	X		X	X	X	X	X	X	X	X	X

X = treatment used

Table 2.3. Drench treatments for study 2. Application rates are in active ingredient per pot.

	DRENCH						
MATERIAL		FLURPRIMIDOL		PACLOBUTRAZOL		UNICONAZOLE	
	Control	Low	High	Low	High	Low	High
RATE	0	10mg	30mg	450.6mg	1351.7mg	9.6mg	28.8mg
Cuphea hyssopifolia green stem	X	X	X	X	X	X	X
Cuphea hyssopifolia red stem	X	X	X	X	X	X	X
Evolvulus glomeratus	X	X	X	X	X	X	X
Wedelia trilobata	X	X	X	X	X	X	X

X = treatment used

RESULTS

Study 1:

Myoporum spp. 'South Coast' Analysis of variance showed no significant differences between treatments until eleven weeks after treatment. Only flurprimidol at the high rate had any significant growth reduction at the 5% level.

Although not statistically significant, paclobutrazol (high rate) and flurprimidol (low rate) treatments also suppressed growth at eight weeks after treatment. (Fig. 2.1) No phytotoxicity was noted for any of the treatments.

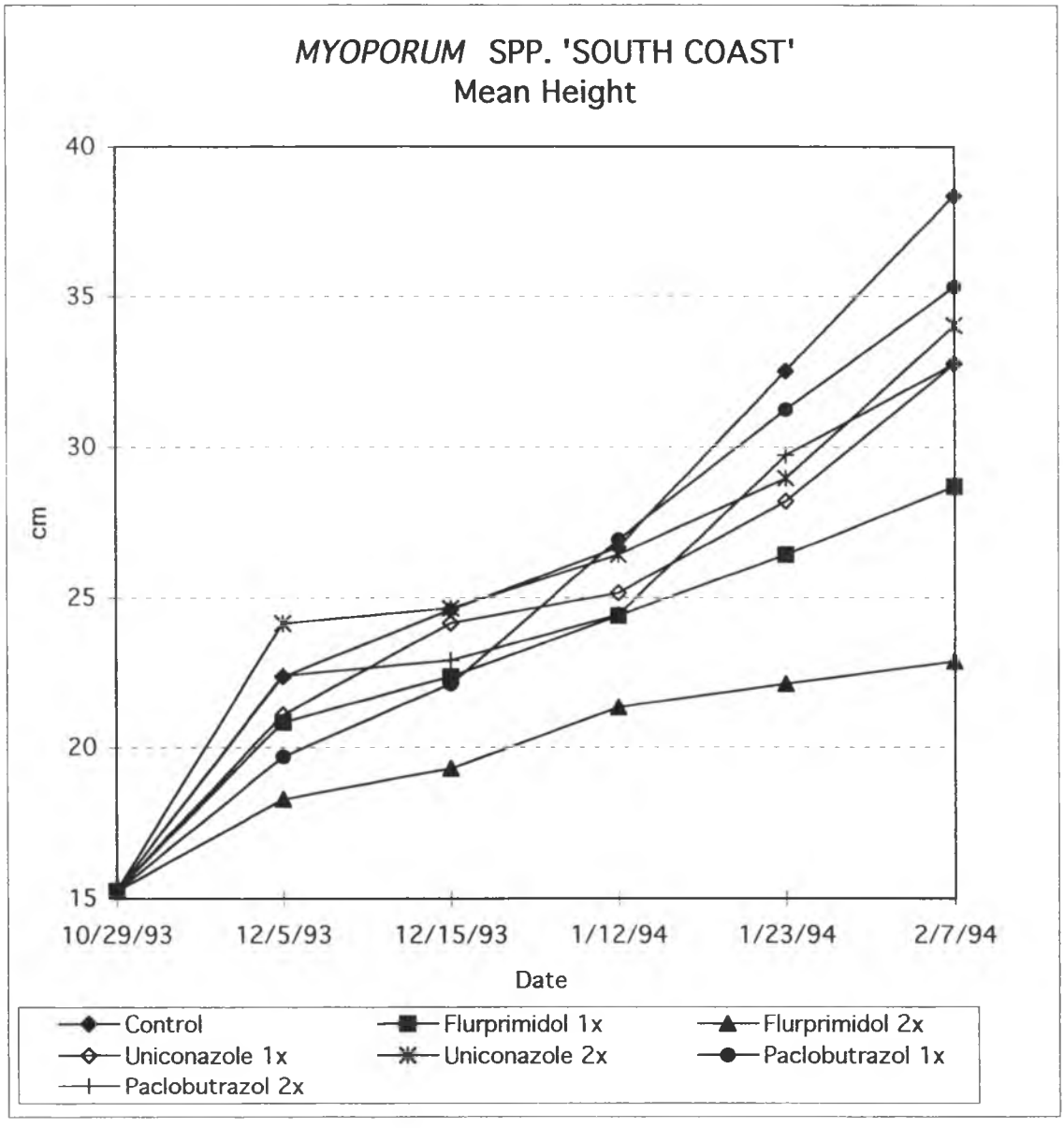
Myoporum spp. 'Davis' Analysis of variance (α = 0.05) showed no significant reduction in growth of *Myoporum* spp. 'Davis' due to drenches of growth regulators at study rates nine weeks after treatment. No phytotoxicity was noted for any treatment. Flurprimidol and paclobutrazol showed significant growth reduction at the 5% level at the high and low rates. Although both materials visually showed some reduction in growth within three weeks after treatment, flurprimidol (high rate) and paclobutrazol (low rate) did not statistically reduce growth until nine weeks after application (Fig. 2.2). The low rate of flurprimidol and the high rate of paclobutrazol did not significantly reduce growth until eleven weeks after treatment. For the first nine weeks of the study, paclobutrazol at the low rate had greater growth regulation than at the high rate.

Neither uniconazole treatment had any significant growth reduction during the study. Plant growth of low rate treatments was consistently greater than that of the control plants.

	10/29/93	12/5/93	12/15/93	1/12/94	1/23/94	2/7/94
Control	15.2	22.4	24.6	26.7	32.5	38.4
Flurprimidol 1x	15.2	20.8	22.4	24.4	26.4	28.7
Flurprimidol 2x	15.2	18.3	19.3	21.3	22.1	22.9
Uniconazole 1x	15.2	21.1	24.1	25.1	28.2	32.8
Uniconazole 2x	15.2	24.1	24.6	26.4	29.0	34.0
Paclobutrazol 1x	15.2	19.7	22.1	26.9	31.2	35.3
Paclobutrazol 2x	15.2	22.4	22.9	24.4	29.7	32.8

Table 2.4: Mean height (cm) of *Myoporum 'South Coast'* spray treatments in greenhouse

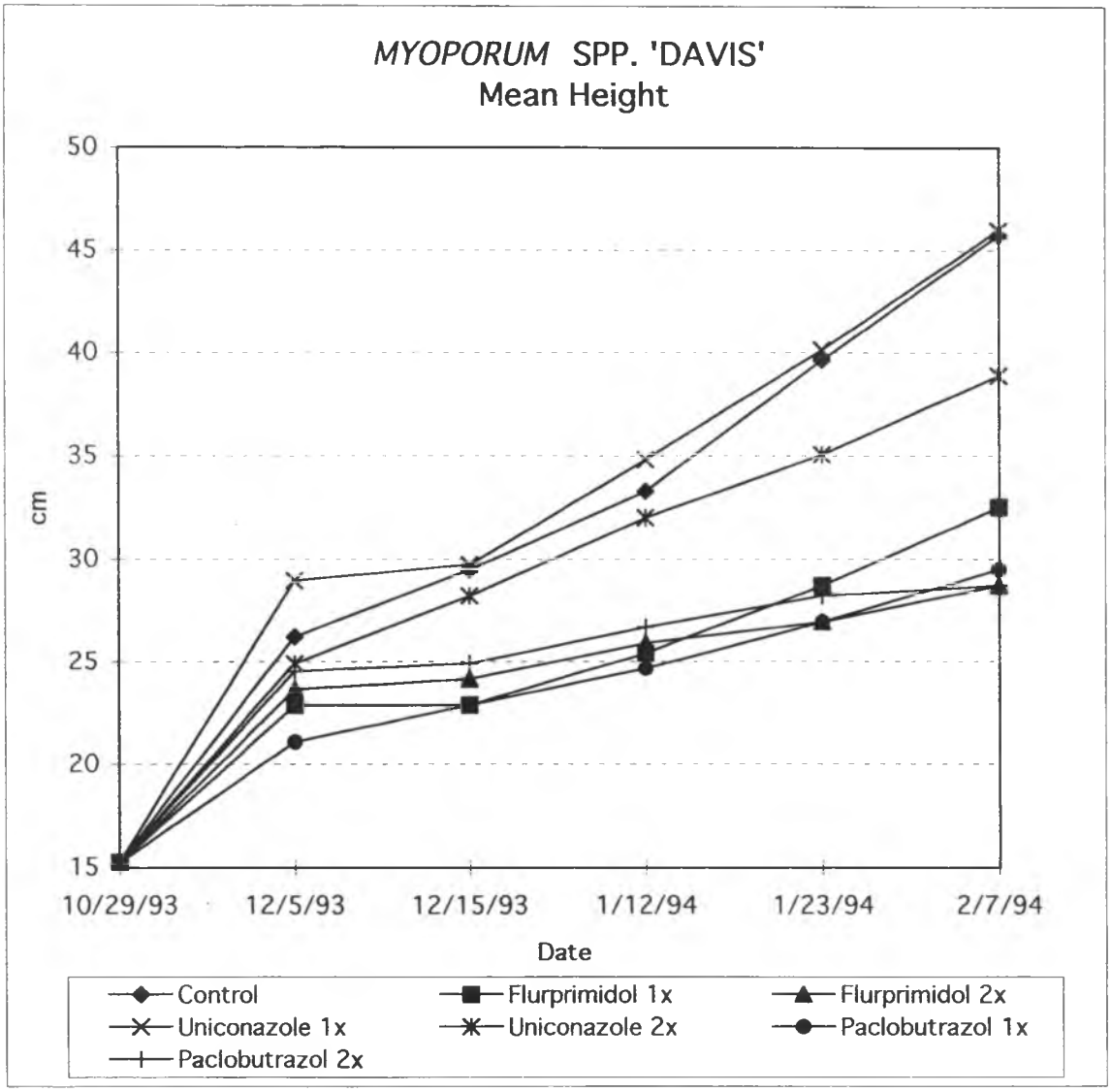
Fig. 2.1: Mean height (cm) of *Myoporum 'South Coast'* spray treatments in greenhouse



	10/29/93	12/5/93	12/15/93	1/12/94	1/23/94	2/7/94
Control	15.2	26.2	29.5	33.3	39.6	45.7
Flurprimidol 1x	15.2	22.9	22.9	25.4	28.7	32.5
Flurprimidol 2x	15.2	23.6	24.1	25.9	26.9	28.7
Uniconazole 1x	15.2	29.0	29.7	34.8	40.1	46.0
Uniconazole 2x	15.2	24.9	28.2	32.0	35.1	38.9
Paclobutrazol 1x	15.2	21.1	22.9	24.6	26.9	29.5
Paclobutrazol 2x	15.2	24.5	24.9	26.7	28.2	28.7

Table 2.5: Mean height (cm) of *Myoporum 'Davis'* spray treatments at Magoon Greenhouse

Fig. 2.2: Mean height (cm) of *Myoporum 'Davis'* spray treatments at Magoon Greenhouse



Evolvulus glomeratus Growth was significantly reduced (α=0.05) two weeks after treatment until the end of the study. The high rate of paclobutrazol significantly reduced growth beginning two weeks after treatment until the end of the study (Fig. 2.3). Flurprimidol and low rates of paclobutrazol had significant growth regulation starting eight weeks after treatment, although all three treatments visually reduced growth at three weeks after treatment. Uniconazole treatments had no significant growth reduction.

Some phytotoxicity (necrosis of the leaf margins) resulted from high rates of flurprimidol and paclobutrazol. Although damage occurred, it was at a minimal level and would not detract from plant quality. All signs of phytotoxicity had grown out by eight weeks after treatment.

Study 2:

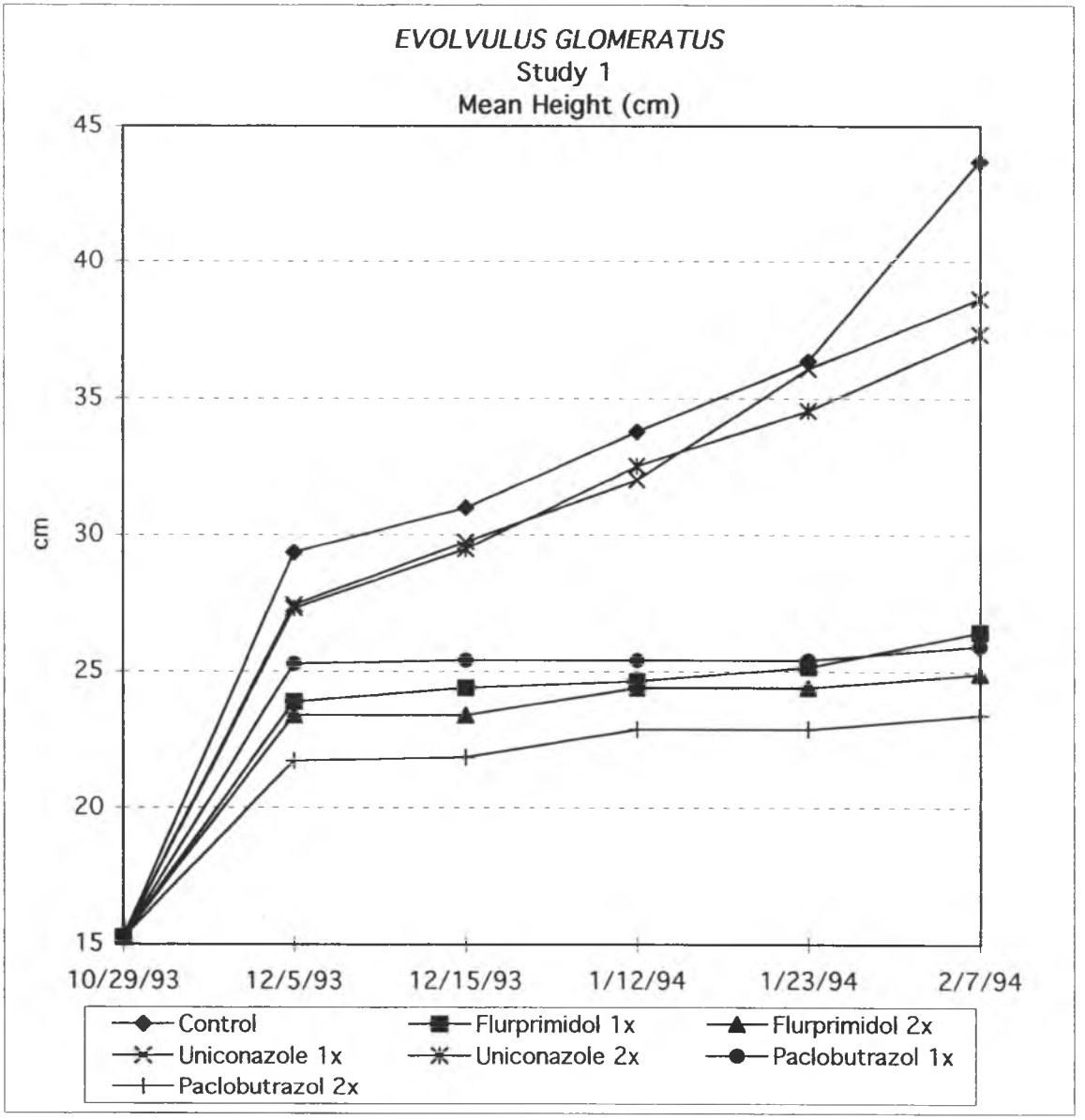
Cuphea hyssopifolia (green stemmed): All treatments significantly reduced growth of the green stemmed variety of *Cuphea hyssopifolia* at the 5% level throughout the study. Flurprimidol drench treatments had zero growth for six weeks (Fig. 2.4). Average heights for drench treatments were less than those of the spray treatments, but differences were not significant.

Flurprimidol spray treatments caused some necrosis of the leaf margins, but at minimal levels. Damage was obvious within two weeks after treatment and lasted for two months. Paclobutrazol and flurprimidol drenches resulted in unacceptable amounts of leaf drop and distortion, especially at high rates. Dikegulac treatments caused a noticeable increase in flowering.

	10/29/93	12/5/93	12/15/93	1/12/94	1/23/94	2/7/94
Control	15.2	29.3	31.0	33.8	36.4	43.7
Flurprimidol 1x	15.2	23.9	24.4	24.6	25.1	26.4
Flurprimidol 2x	15.2	23.4	23.4	24.4	24.4	24.9
Uniconazole 1x	15.2	27.4	29.7	32.0	36.1	38.6
Uniconazole 2x	15.2	27.3	29.5	32.5	34.5	37.3
Paclobutrazol 1x	15.2	25.3	25.4	25.4	25.4	25.9
Paclobutrazol 2x	15.2	21.7	21.8	22.9	22.9	23.4

Table 2.6: Mean height (cm) of *Evolvulus glomeratus* spray treatments in the greenhouse

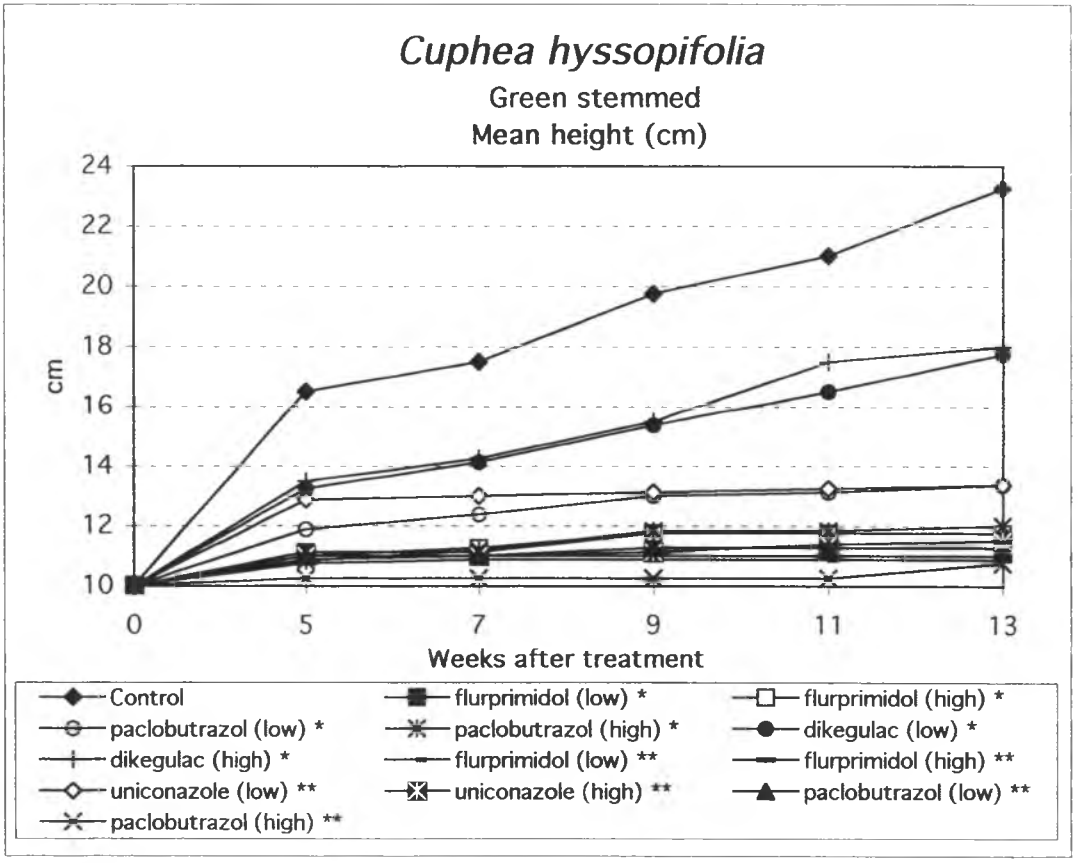
Fig. 2.3: Mean height (cm) of *Evolvulus glomeratus* spray treatments in the greenhouse



	WEEKS AFTER TREATMENT					
	0	5	7	9	11	13
Control	10.0	16.5	17.5	19.8	21.0	23.3
flurprimidol (low) *	10.0	11.1	11.1	11.8	11.8	11.8
flurprimidol (high) *	10.0	11.0	11.3	11.8	11.8	11.8
paclobutrazol (low) *	10.0	11.9	12.4	13.0	13.1	13.4
paclobutrazol (high) *	10.0	10.8	11.2	11.8	11.8	12.0
dikegulac (low) *	10.0	13.3	14.1	15.4	16.5	17.8
dikegulac (high) *	10.0	13.5	14.3	15.5	17.5	18.0
flurprimidol (low) **	10.0	10.8	10.9	10.9	10.9	10.9
flurprimidol (high) **	10.0	10.9	11.0	11.0	11.0	11.0
uniconazole (low) **	10.0	12.9	13.0	13.1	13.3	13.4
uniconazole (high) **	10.0	11.0	11.0	11.1	11.4	11.5
paclobutrazol (low) **	10.0	11.0	11.0	11.3	11.3	11.3
paclobutrazol (high) **	10.0	10.3	10.3	10.3	10.3	10.8

Table 2.7: Mean height (cm) of green stemmed *Cuphea hyssopifolia* , Magoon Greenhouse, UH-Manoa.
** = spray applications ** = drench applications*

Fig. 2.4: Mean height (cm) of green stemmed *Cuphea hyssopifolia* , Magoon Greenhouse, UH-Manoa.



Cuphea hyssopifolia (red stemmed): All treatments significantly controlled growth the red stemmed variety of *Cuphea hyssopifolia* at the 5% level. Dikegulac treatments slowed growth for the first twelve weeks after treatment (Fig. 2.5). Low rates of uniconazole showed significant growth reduction beginning twelve weeks after treatment and lasted for two weeks. All other treatments controlled growth throughout the length of the study.

All flurprimidol and paclobutrazol treatments resulted in leaf burning and leaf drop. Phytotoxicity at high rates caused more damage. Plants would not be acceptable in the landscape. New leaf growth was small and distorted.

Drench treatments caused greater growth reduction over spray treatments, but not at significant levels.

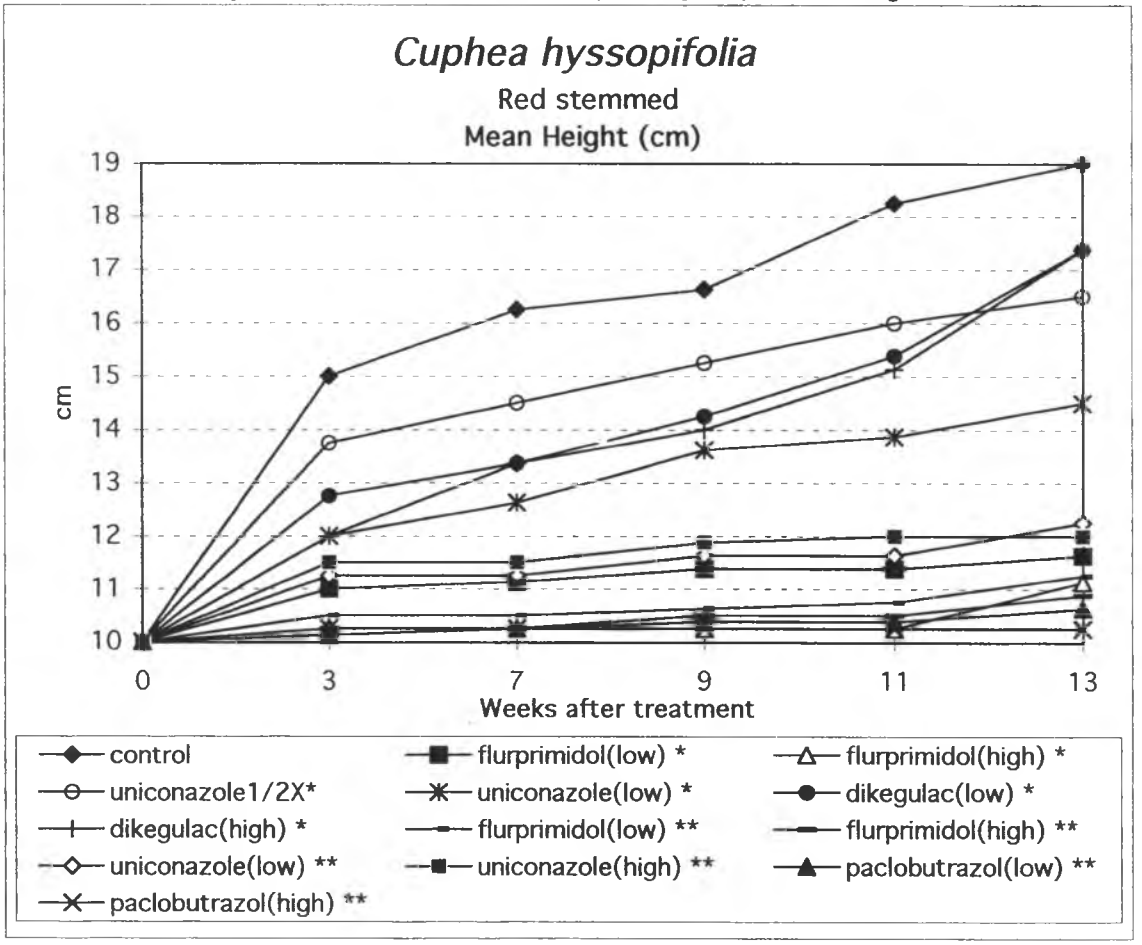
Evolvulus glomeratus: Differences among treatments were significant at the 0.05 level throughout the study. Flurprimidol and paclobutrazol drench treatments reduced growth beginning three weeks after treatment and lasting until the end of the study (Fig. 2.6). All other treatments, with the exception of paclobutrazol sprayed at low rates, showed significant growth reduction beginning seven weeks after treatment. Dikegulac treatments, and high spray treatments of uniconazole lasted for five weeks. The other treatments lasted until the end of the study. Paclobutrazol at the low spray rates did not control growth until nine weeks after treatment and lasted for three weeks.

High rates of flurprimidol and paclobutrazol applications, and low drench rates of paclobutrazol caused foliage damage. Symptoms showed within two weeks after treatment and lasted for the entire study. Damage included leaf

	WEEKS AFTER TREATMENT					
	0	3	7	9	11	13
control	10.0	15.0	16.3	16.6	18.3	19.0
flurprimidol(low) *	10.0	11.0	11.1	11.4	11.4	11.6
flurprimidol(high) *	10.0	10.3	10.3	10.3	10.3	11.1
uniconazole1/2X*	10.0	13.8	14.5	15.3	16.0	16.5
uniconazole(low) *	10.0	12.0	12.6	13.6	13.9	14.5
dikegulac(low) *	10.0	12.8	13.4	14.3	15.4	17.4
dikegulac(high) *	10.0	12.0	13.4	14.0	15.1	17.4
flurprimidol(low) **	10.0	10.5	10.5	10.6	10.8	11.3
flurprimidol(high) **	10.0	10.3	10.3	10.5	10.5	10.9
uniconazole(low) **	10.0	11.3	11.3	11.6	11.6	12.3
uniconazole(high) **	10.0	11.5	11.5	11.9	12.0	12.0
paclobutrazol(low) **	10.0	10.1	10.3	10.4	10.4	10.6
paclobutrazol(high) **	10.0	10.3	10.3	10.3	10.3	10.3

Table 2.8: Mean ht. (cm) of red stemmed *Cuphea hyssopifolia* , Magoon Greenhouse
** = spray applications ** = drench applications*

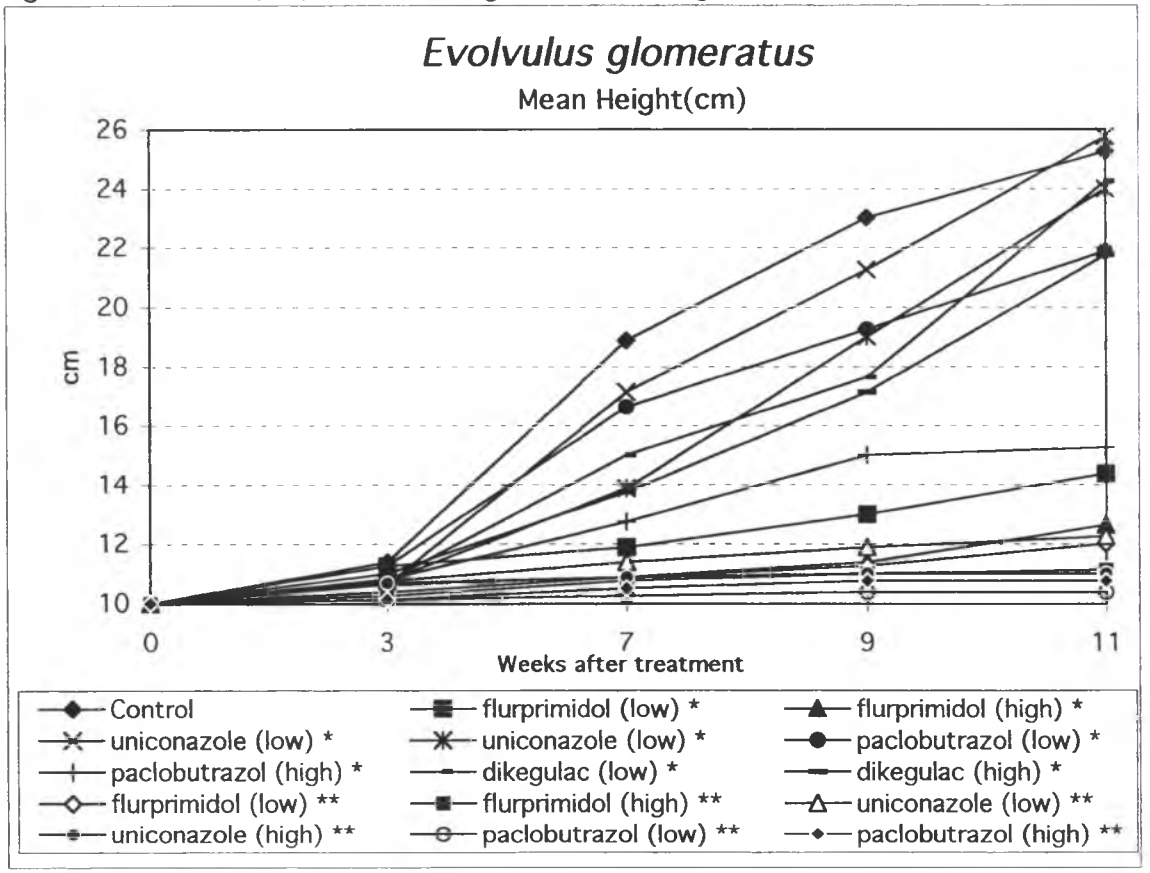
Fig. 2.5: Mean height (cm) of red stemmed *Cuphea hyssopifolia* , Magoon Greenhouse



	WEEKS AFTER TREATMENT				
	0	3	7	9	11
Control	10.0	11.4	18.9	23.0	25.3
flurprimidol (low) *	10.0	11.3	11.9	13.0	14.4
flurprimidol (high) *	10.0	10.6	10.9	11.4	12.6
uniconazole (low) *	10.0	10.6	17.1	21.3	25.8
uniconazole (low) *	10.0	10.8	13.9	19.0	24.0
paclobutrazol (low) *	10.0	11.3	16.6	19.3	21.9
paclobutrazol (high) *	10.0	10.8	12.8	15.0	15.3
dikegulac (low) *	10.0	10.8	15.0	17.6	24.3
dikegulac (high) *	10.0	11.0	13.8	17.1	21.8
flurprimidol (low) **	10.0	10.4	10.9	11.3	12.0
flurprimidol (high) **	10.0	10.3	10.8	11.0	11.1
uniconazole (low) **	10.0	10.8	11.4	11.9	12.3
uniconazole (high) **	10.0	10.7	10.9	11.0	11.0
paclobutrazol (low) **	10.0	10.1	10.3	10.4	10.4
paclobutrazol (high) **	10.0	10.1	10.5	10.8	10.8

Table 2.9: Mean ht. (cm) of *Evolvulus glomeratus* , Magoon Greenhouse
* = spray applications ** = drench applications

Fig. 2.6: Mean ht. (cm) of *Evolvulus glomeratus* , Magoon Greenhouse



burning and severe stunting. Uniconazole treatments caused some decrease in quality, but at levels that would be acceptable in the landscape

Liriope muscari: An analysis of variance and mean separation showed all treatments significantly reduced growth over control throughout the study (Fig. 2.7). Flurprimidol treatments caused the greatest reduction in growth, limiting plant height to 37% of the control by the end of the study (Table 2.8).

Phytotoxicity was caused by high rates of paclobutrazol and uniconazole. Damage showed seven weeks after treatment as chlorotic blades as well as the blades being distorted and failing to separate from each other. Symptoms lasted throughout the study.

Wedelia trilobata: An analysis of variance showed treatments were significantly different at the 0.05 level throughout the study until trimming at twelve weeks. At that time, there were no differences among treatments.

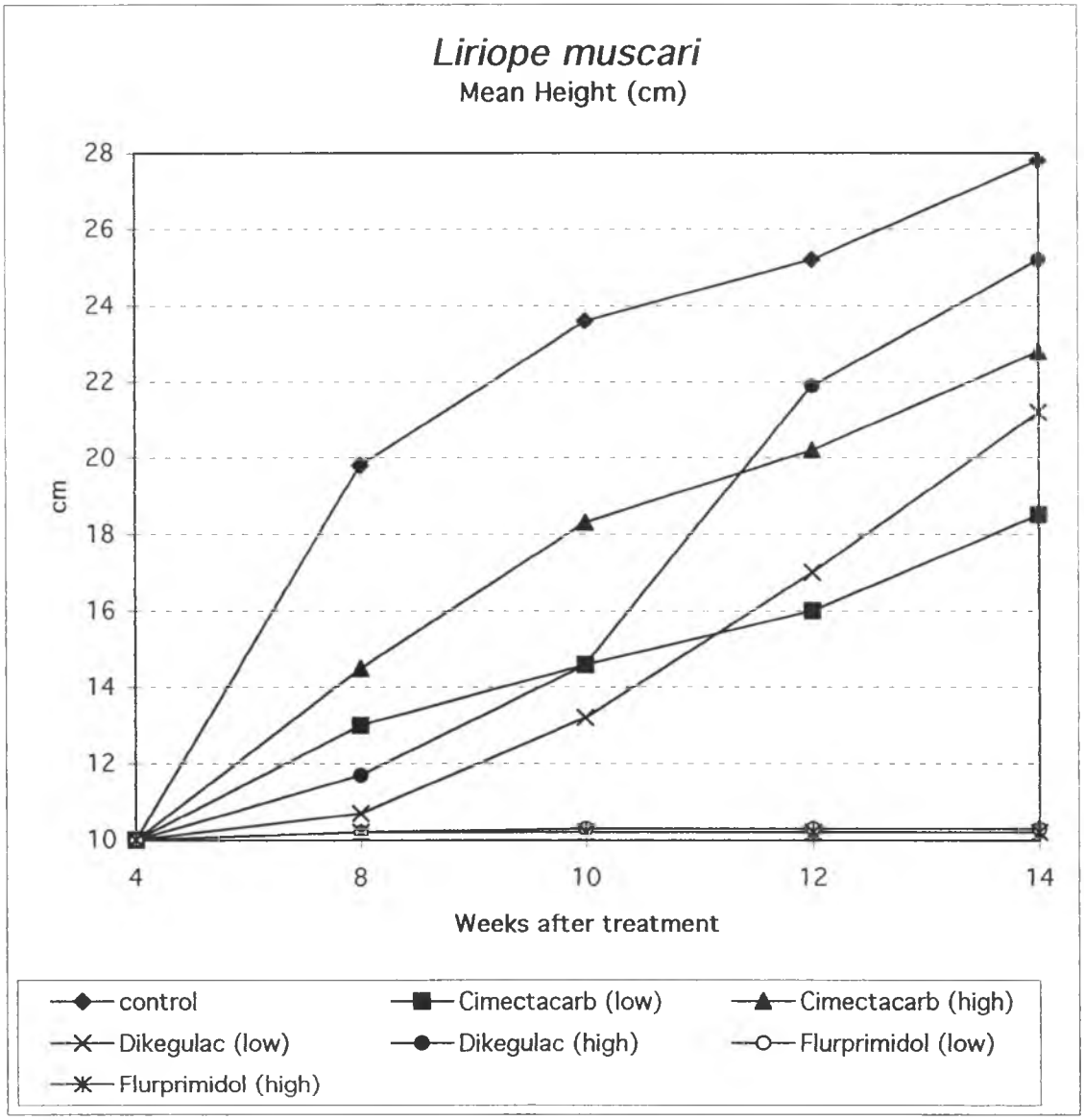
All cimectacarb, flurprimidol, and paclobutrazol treatments significantly controlled growth within three weeks after treatment and lasted until the end of the study (Fig. 2.8). Dikegulac spray treatments controlled growth beginning three weeks after treatment and lasted for two weeks at the low rates and five weeks at the high rates. There were no dikegulac drench treatments. Uniconazole drench treatments at the high rate significantly controlled growth beginning five weeks after treatment and lasted for three weeks.

At the end of the study, average height was 26% and 33% of control for flurprimidol spray drench treatments at the high rates, 30% for paclobutrazol drench at the low rate, and 35% for cimectacarb at the high.

SPRAY TREATMENT	WEEKS AFTER TREATMENT 3.5	7.6	9.6	12	13.6
control	10	19.8	23.6	25.2	27.8
Cimectacarb (low)	10	13	14.6	16	18.5
Cimectacarb (high)	10	14.5	18.3	20.2	22.8
Dikegulac (low)	10	10.7	13.2	17	21.2
Dikegulac (high)	10	11.7	14.6	21.9	25.2
Flurprimidol (low)	10	10.2	10.3	10.3	10.3
Flurprimidol (high)	10	10.2	10.2	10.2	10.2

Table 2.10: Mean height (cm) of *Liriope muscari* , Magoon Greenhouse

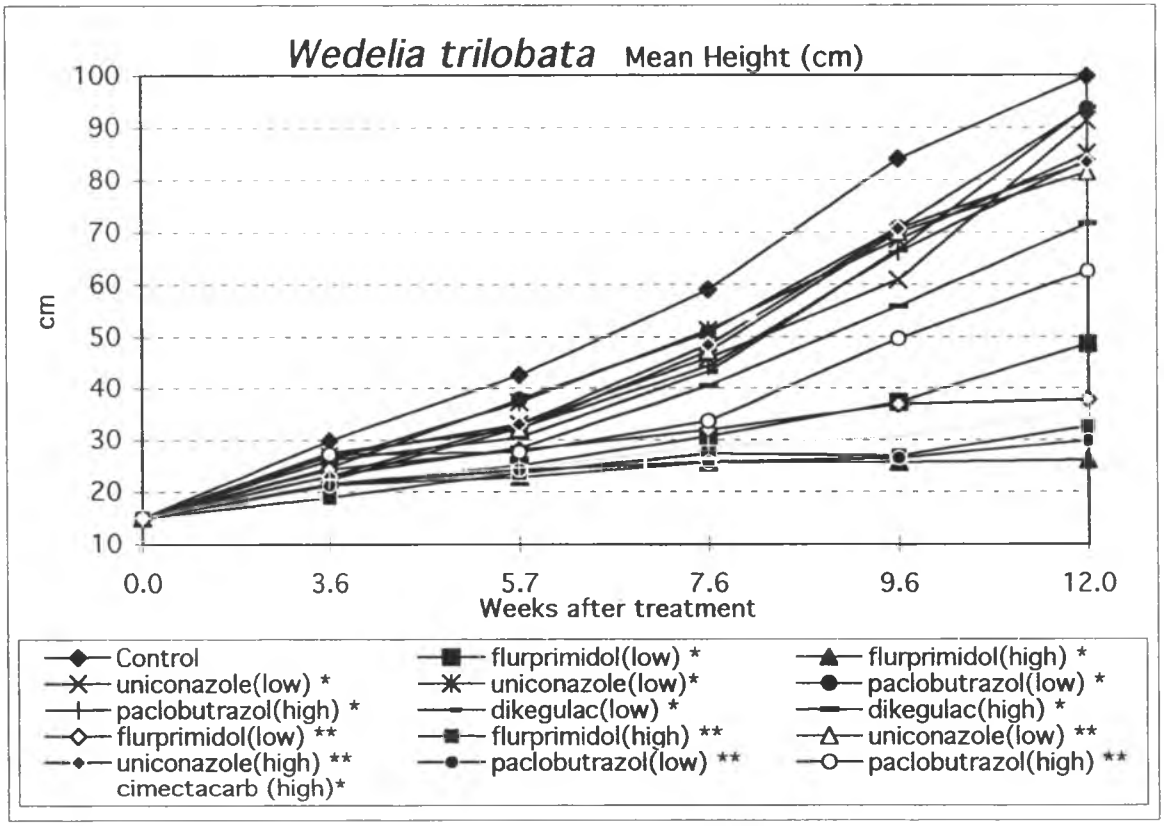
Fig. 2.7: Mean height (cm) of *Liriope muscari* , Magoon Greenhouse



	WEEKS AFTER TREATMENT					
	0	3.6	5.7	7.6	9.6	12
Control	15	29.8	42.4	59	84	99.8
flurprimidol(low) *	15	21.4	25	30.6	37.2	48.6
flurprimidol(high) *	15	21.2	22.8	25.6	25.6	26
uniconazole(low) *	15	26.8	33	45.8	60.8	91.2
uniconazole(low)*	15	26	37.2	51.2	68.6	85
paclobutrazol(low) *	15	24.6	37.8	50.8	70.8	93.6
paclobutrazol(high) *	15	22.2	32.2	44.2	66.2	83.8
dikegulac(low) *	15	26	30.4	43.2	66.6	93.8
dikegulac(high) *	15	23.1	28.4	40.4	55.8	71.6
flurprimidol(low) **	15	24.3	28	31.8	36.8	37.8
flurprimidol(high) **	15	18.9	23.6	27.2	26.8	32.6
uniconazole(low) **	15	27.4	32	47.1	70	81.4
uniconazole(high) **	15	23	33	48.4	70.6	83.4
paclobutrazol(low) **	15	21.2	24.2	25.6	26.4	29.8
paclobutrazol(high) **	15	27.1	27.6	33.6	49.6	62.6
cimectacarb (high)*	15	22.2	24.6	28.8	30.8	35.4

Table 2.11: Mean ht. (cm) of *Wedelia trilobata* , Magoon Greenhouse
* = spray applications ** = drench applications

Fig. 2.8: Mean ht. (cm) of *Wedelia trilobata* , Magoon Greenhouse



Flurprimidol treatments at the high rate caused some phytotoxicity for the first four weeks of the study. Damage was at a level acceptable in the landscape and was grown out by six weeks after treatment. Paclobutrazol drench treatments showed severe damage throughout the study, including leaf and stem tip burning and severe stunting.

There was no significant difference between spray and drench treatments although heights for drench treatments were generally less than those of the spray treatments.

DISCUSSION

These preliminary studies showed that rates used in published studies, as well as label rates were a good starting point for further work. All rates exhibited some growth reduction on all species tested, although not always statistically significant. In Study 1, both paclobutrazol and flurprimidol reduced growth more than uniconazole, indicating that rates needed to be higher for uniconazole in later studies. Increased rates for paclobutrazol and flurprimidol were also needed due to the long delays for growth reduction to occur, especially in the two *Myoporum* species. This study also showed that the effects of the growth regulators are species dependent for paclobutrazol and flurprimidol. *Evolvulus glomeratus* was more affected in terms of growth reduction and phytotoxicity than the two *Myoporum* species

In Study 2, paclobutrazol and flurprimidol had the greatest affect on growth reduction, although high rates caused phytotoxic damage to all species tested, some severely. Drench treatments generally caused more growth reduction than spray treatments.

CHAPTER III

FIELD EVALUATION OF SEVERAL GROWTH REGULATORS ON *WEDELIA TRILOBATA* AND *EVOLVULUS GLOMERATUS*

INTRODUCTION

There is little information available about the use of recent generation growth regulators as a maintenance tool for established landscape plants, with the exception of turf and tree growth regulators. Few studies have been done on controlling groundcovers in the landscape. Chlorflurenol controlled *Wedelia trilobata* in the field for a period of 12 weeks (Criley, 1976). There was little or no effect on growth from ancymidol, chlormequat and daminozide. The majority of published research has involved potted landscape plants rather than those under field conditions. Paclobutrazol and uniconazole controlled growth of *Brassia actinophylla, Codiaeum variegatum* and *Syngonium podophyllum*, although degree of control was dependent upon both rate and method of application, either spray or drench (Wang and Blessington, 1990) Both materials severely retarded *Plectranthus australis*.

MATERIALS AND METHODS

Study 1 (at UH Waimanalo Research Station):

The objectives of this study were to:

1. Evaluate materials for length and degree of control.
2. Evaluate materials for phytotoxicity.

2. Evaluate materials for phytotoxicity.
3. Determine effective rates in a field setting.

Rooted cuttings of *Evolvulus glomeratus* and *Wedelia trilobata*, grown in the shadehouse in one-quart pots, were planted 30cm on center in the field at the University of Hawai'i Waimanalo Experiment Station on June 16, 1994. Plants were allowed to fill in the rows before being treated. The rows were 45m long and spaced 60cm apart from center. Each experimental unit consisted of 4 plants. They were arranged in a randomized complete design with four replications of each treatment.

The plants were irrigated with drip irrigation daily for 10 minutes. On July 7, 1994, ammonium sulfate (21N-0P-0K) was applied at a rate of $1 kg \cdot m^{-2}$. On September 9, 1994, the rows of *W. trilobata* were trimmed to a width of 45cm, and rows of *E. glomeratus* trimmed to a width of 30cm. Row widths were marked with string on both sides of the rows. On September 14, 1995, plants were sprayed with the growth regulator treatments. Treatments consisted of an untreated control and low, medium, and high rates of various growth regulators. (Tables 3.1, 3.2). Low rates were based on previous shadehouse studies. Width measurements (growth) and quality evaluations (phytotoxicity) were taken every two weeks.

Table 3.1. Treatment rates for *Evolvulus glomeratus* grown at UH-Waimanalo Experiment station. Rates are in amount of active ingredient $1000m^{-2}$.

	APPLICATION RATE		
MATERIAL	LOW	MEDIUM	HIGH
Control	0	0	0
Cimectacarb	168ml	336ml	0
Dikegulac	130ml	260ml	0
Flurprimidol	170g	340g	0
Paclobutrazol	34ml	68ml	136ml
Uniconazole	5ml	10ml	0

Table 3.2. Treatment rates for *Wedelia trilobata* grown at UH-Waimanalo Experiment station. Rates are in amount of active ingredient $1000m^{-2}$.

	APPLICATION RATE		
MATERIAL	LOW	MEDIUM	HIGH
Control	0	0	0
Cimectacarb	168ml	336ml	672ml
Dikegulac	0	260ml	520ml
Flurprimidol	170g	340g	680g
Paclobutrazol	34ml	68ml	136ml
Uniconazole	5ml	10ml	20ml

Study 2 (at Kapolei Golf Course):

The objectives of this study were to:

1. evaluate degree and length of control;
2. evaluate materials for phytotoxicity;
3. determine effective rates in a field setting; and to
4. determine effective application timing after trimming.

Three studies were conducted on established beds of *Wedelia trilobata* at the Kapolei Golf Course in Kapolei, Oahu, Hawai'i, in cooperation with Mahana Landscaping, Inc. Treatment plots of 0.85m^2, separated by a 0.30m buffer, were replicated three times and arranged in randomized complete blocks. Growth regulators were applied as a spray solution in 200ml of water per plot at three rates based on previous shadehouse studies (table 3.3). Controls were not treated. Beds were irrigated nightly for twenty minutes. Ammonium sulfate (21-0-0) was applied on a regular basis.

Application 1 (application immediately after mowing): Treatment plot 1 was mowed to 4cm with a string trimmer on July 18, 1994, and treated one day later with growth regulators on July 19, 1994. Height measurements and quality evaluations were taken every two weeks for 14 weeks after treatment.

Application 2 (application in three weeks after mowing): Treatment plot 2 was mowed to 4cm with a string trimmer on August 24, 1994 and treated with growth regulators three weeks later on September 7, 1994. The area was again trimmed to 4cm on December 4, 1994. Height measurements and quality evaluations were taken every two weeks for 21 weeks after treatment.

Application 3 (application in five weeks after mowing): Treatment plot 3 was mowed to 4cm with a string trimmer on August 24, 1994 and treated with growth regulators five weeks later on September 28, 1994. It was again trimmed to 4cm on December 4, 1994. Height measurements and quality evaluations were taken every two weeks for 18 weeks after treatment.

Table 3.3. Growth regulator application rates for *Wedelia trilobata* grown at Kapolei golf course. Rates are in amount of active ingredient m^{-2}.

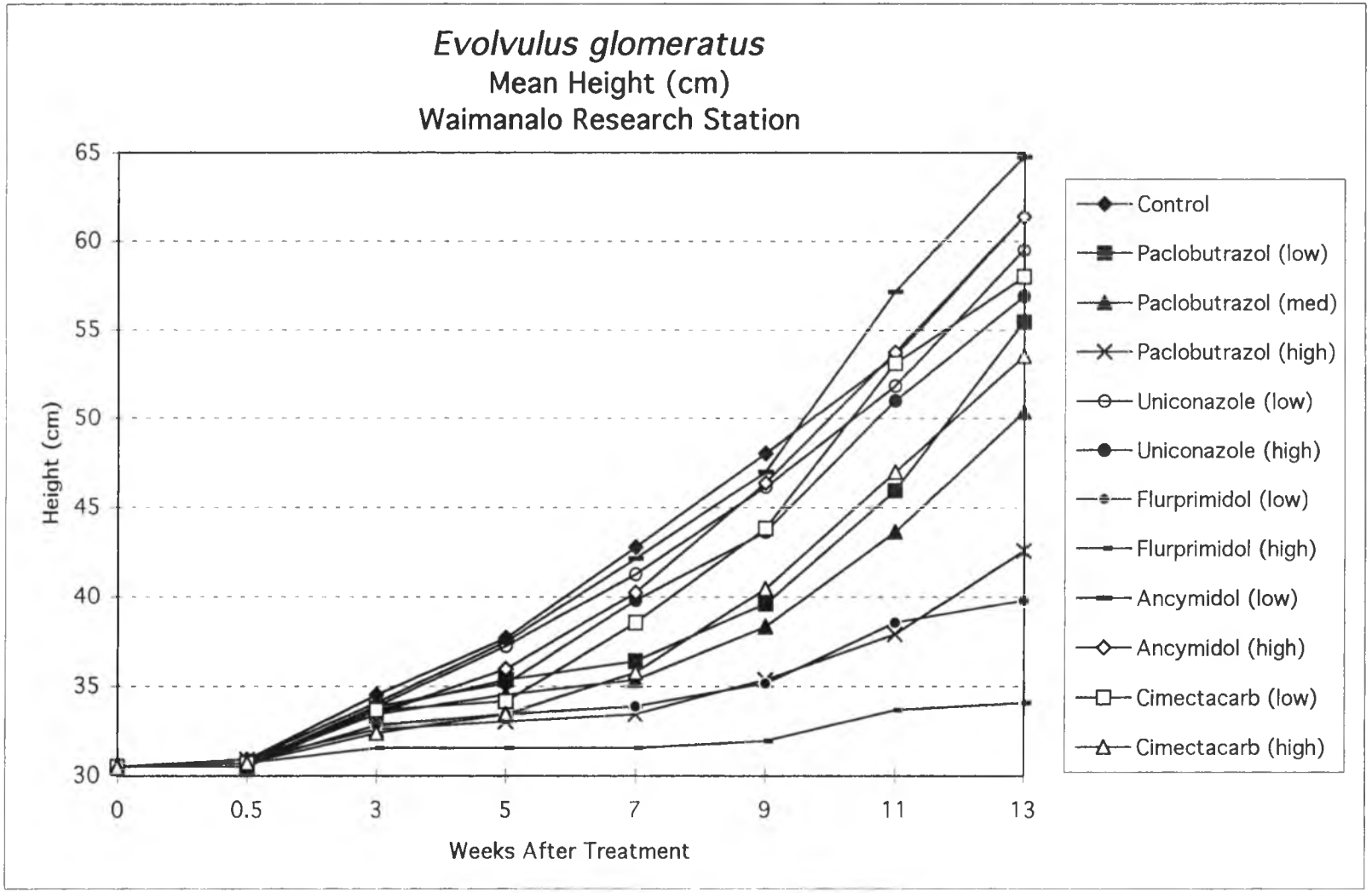
	APPLICATION RATE		
MATERIAL	**LOW**	**MED**	**HIGH**
Cimectacarb	0.7ml	1.3ml	2.7ml
Dikegulac	112.2mg	224.3mg	448.6mg
Flurprimidol	170.0mg	340.0mg	680.0mg
Paclobutrazol	37.3mg	74.5mg	149.1mg
Uniconazole	4.9mg	9.8mg	19.6mg

RESULTS

Study 1: University of Hawai'i Waimanalo Research Station

Evolvulus glomeratus: Analysis of variance (α=0.05) showed a statistically significant difference among treatments beginning 3 weeks after treatment until the end of the study at 13 weeks after treatment (Fig. 3.1). Treatments of high rates of cimectacarb, flurprimidol and paclobutrazol significantly reduced growth compared to the control at 3 weeks after treatment until the end of the study. Beginning 5 weeks after treatment, low and medium

Fig. 3.1: Mean height (cm) of *Evolvulus glomeratus* at Waimanalo Research Station, University of Hawai'i.

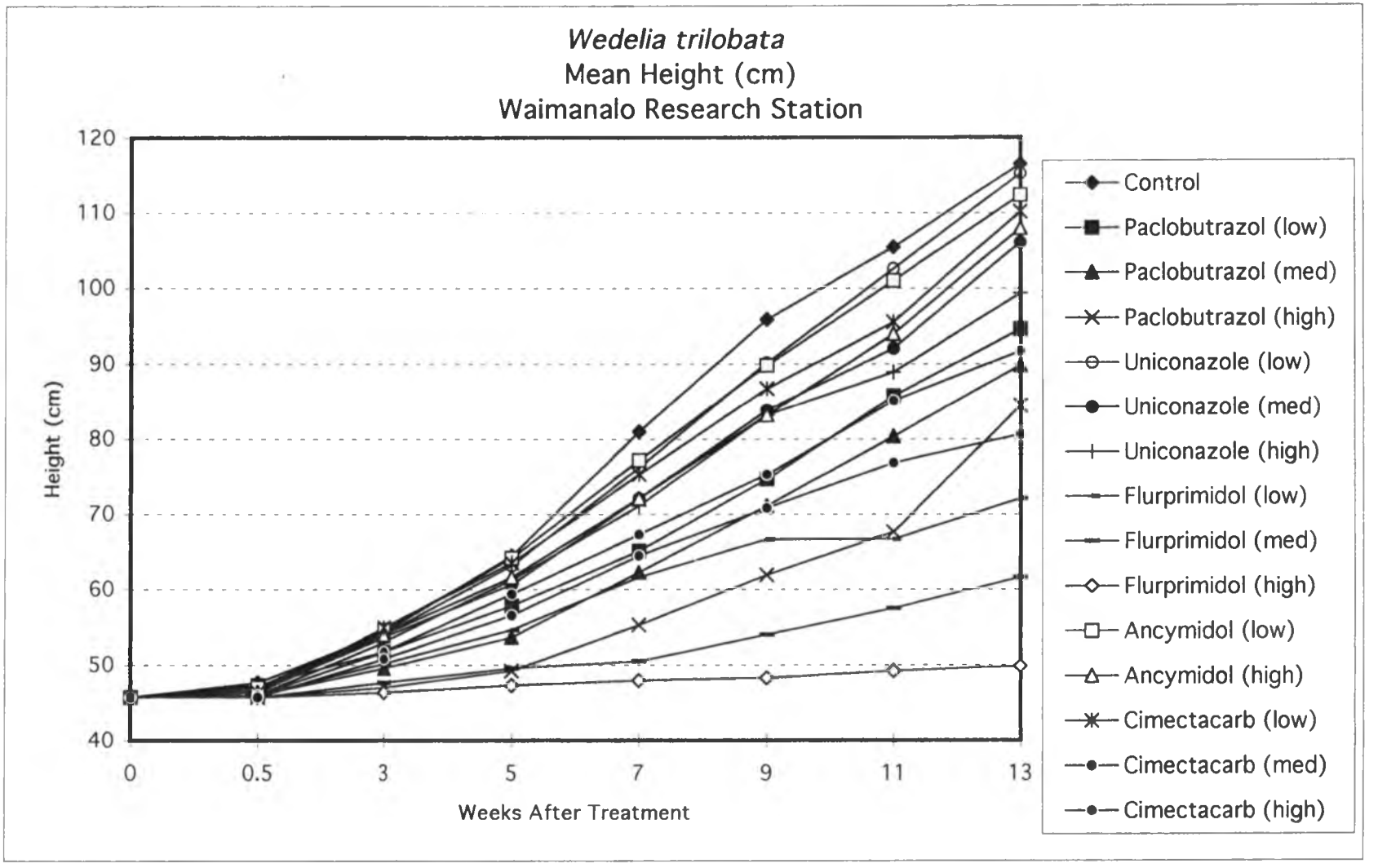


rates of paclobutrazol and low rates of flurprimidol significantly controlled growth until the end of the study. Cimectacarb at the low rate significantly controlled growth from week 5 to week 9. High rates of ancymidol and uniconazole significantly reduced growth over control form week 5 to 7, while low rates showed no statistically significant control throughout the study. By 11 weeks after treatment, growth from both ancymidol applications had surpassed that of the control.

Phytotoxicity in the form of chlorotic leaves and necrosis of the leaf margins, was noted in high application rates of flurprimidol and uniconazole and low and high rates of paclobutrazol, although damage was no longer evident in flurprimidol treatments by 5 weeks after treatment. There was slight foliar necrosis from low rates of flurprimidol and uniconizole, but at a level acceptable in the landscape. High rates of cimectacarb caused necrosis of the stem tips. High rates of flurprimidol also appeared to cause a delay in flowering, but not in the quantity of flowers.

Wedelia trilobata: Analysis of variance (α=0.05) showed a significant difference among treatments beginning one week after treatment until the end of the study at 13 weeks, with high rates of cimectacarb and paclobutrazol and medium and high rates of flurprimidol showing significant reduction of growth compared to control treatments (Fig. 3.2). Other treatments lasting throughout the study were low rates of flurprimidol and medium rates of paclobutrazol beginning 3 weeks after treatment, low rates of paclobutrazol at week 5, and high rates of ancymidol, medium rates of cimectacarb, and medium and high rates of uniconazole beginning at week 7. Low rates of ancymidol and cimectacarb significantly reduced growth from week 9 to 11. Low rates of

Fig. 3.2: Mean height (cm) of *Wedelia trilobata* at Waimanalo Research Station, University of Hawai'i.



uniconazole caused no statistically significant reduction in growth, although plant sizes were smaller than those of the controls.

Medium and high rates of flurprimidol caused some foliar discoloration and slight necrosis, but damage was no longer evident by 3 weeks after treatment. High rates of cimectacarb and ancymidol seemed to cause a reduction in amount of flowering by the third week after treatment. No phytotoxicity was noted from other treatments.

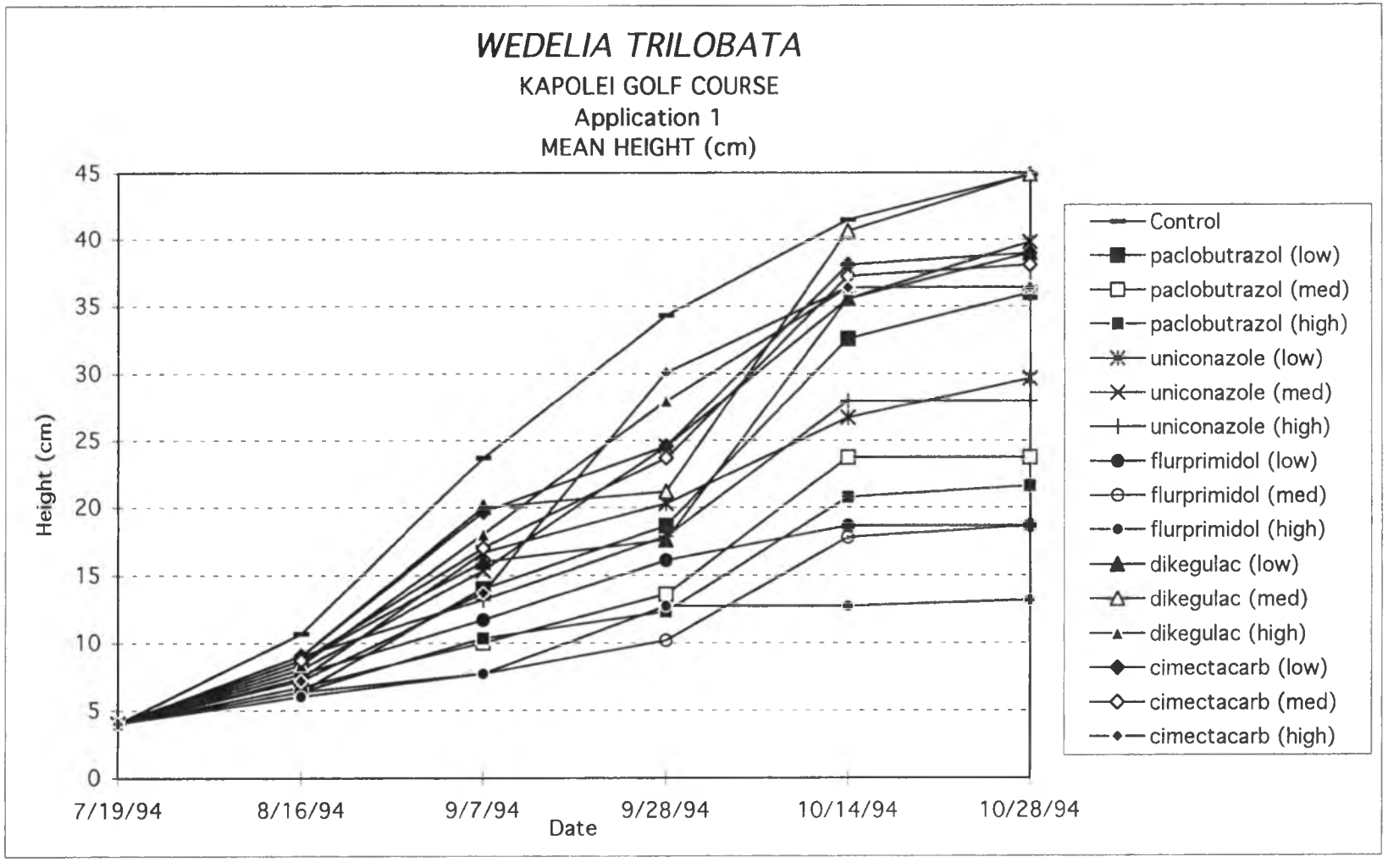
Study 2: Kapolei Golf Course

Application 1: There was a significant difference among growth regulators beginning seven weeks after treatment at the 5% level and lasting throughout the study. Replications were also significantly different throughout the entire study. This is may have been due to uneven irrigation of the plots in this first study.

Flurprimidol at the high rate significantly regulated growth beginning seven weeks after treatment and lasted until the end of the study, except for a two week period at ten weeks after treatment (Fig. 3.3). Flurprimidol at the medium rate controlled growth for a three weeks, starting seven weeks after treatment. All flurprimidol treatments retarded growth over all other treatments.

Plots in this first study looked sparse, especially areas with less irrigation. This was also due to the shorter time allowed for plants to fill in before growth regulators were applied. Medium and high rates of flurprimidol and cimectacarb caused slight leaf necrosis and visually reduced flowering. Treated areas also were darker green than untreated areas, especially paclobutrazol and flurprimidol treatments.

Fig. 3.3: Mean height (cm) of *Wedelia trilobata* at Kapolei Golf Course, Oahu, Hawai'i.
Application 1: Growth regulator treatment one day after mowing.



Application 2: Analysis of variance showed that treatments were significantly different at the 5% level beginning five weeks after treatment until trimming at fourteen weeks (Fig. 3.4). They were again significantly different 21 weeks after treatment. There were no significant differences among replications.

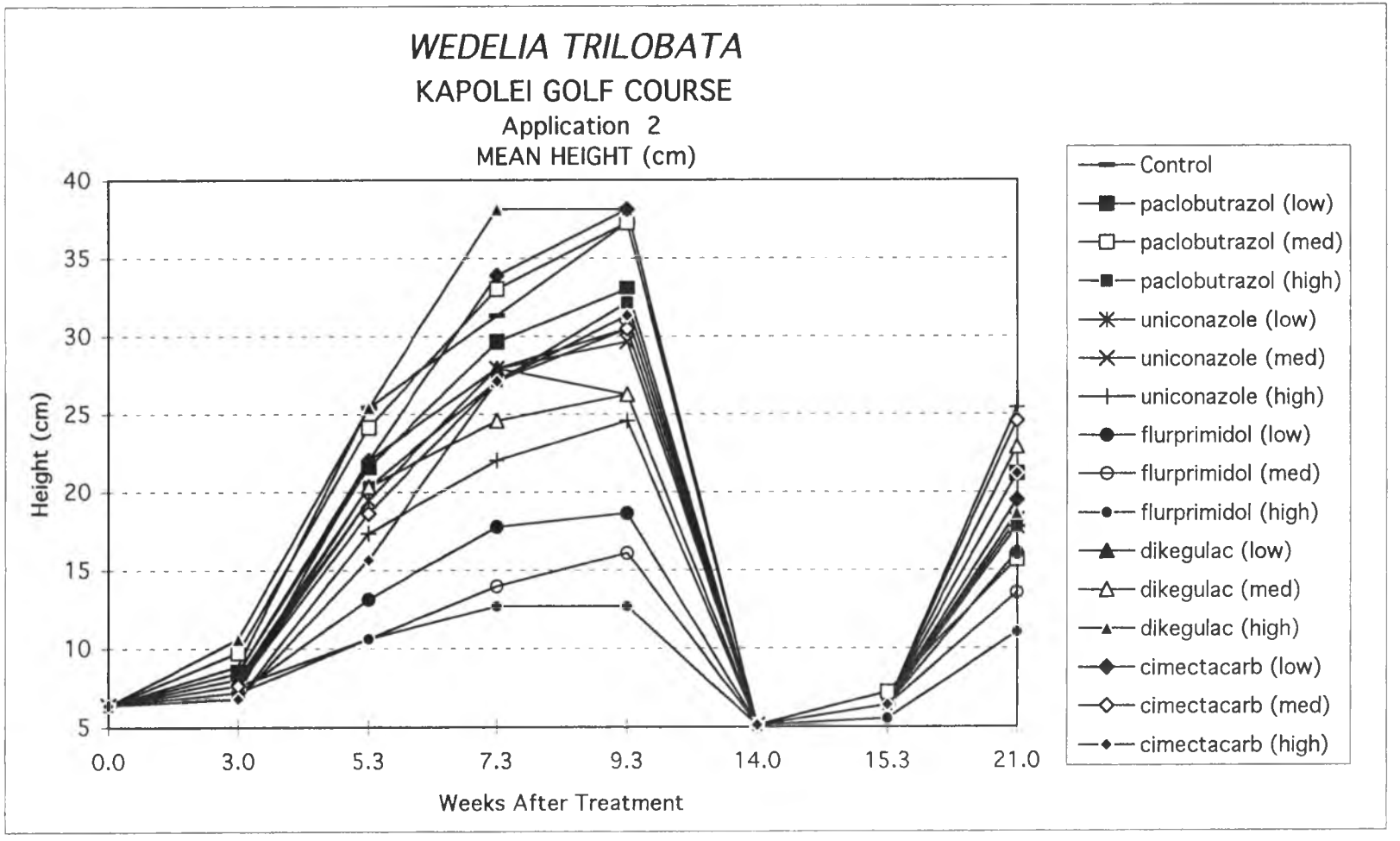
All flurprimidol treatments controlled growth at five weeks after treatment. Low and medium rate treatments lasted for two weeks, while the high rate lasted until trimming and then again seven weeks after trimming. Cimectacarb at the high rate also showed significant control beginning five weeks after treatment and lasted for two weeks. Seven weeks after trimming, heights among the plots were irregular indicating the release of growth regulation, the only exception being flurprimidol at the high rate.

Flurprimidol and paclobutrazol treatments caused foliage to be darker green than untreated areas. Medium and high rates of flurprimidol resulted in some leaf necrosis five weeks after treatment and lasted for two weeks before growing out. Flowers were also had some distortion. Damage was minimal and would still have been acceptable in the landscape. Because the wedelia was allowed to recover from trimming before growth regulators were applied, the foliage had time to fully cover the ground, although it was slower to recover from the second trimming than it was in the third study.

Application 3: There were significant differences among treatments at the 5% level beginning two weeks after treatment and lasting until the second trimming twelve weeks after treatment. They were again significantly different eighteen weeks after treatment.

Mean separation showed high rates of flurprimidol to significantly retard growth starting four weeks after treatment until trimming and afterwards at

Fig. 3.4: Mean height (cm) of *Wedelia trilobata* at Kapolei Golf Course, Oahu, Hawai'i.
Application 2: Growth regulator treatment three weeks after mowing.
Plants were trimmed a second time at week 15.



eighteen weeks after treatment (Fig. 3.5). Low and medium applications of flurprimidol lasted as long, but did not show significant control until six weeks after treatment. Low and medium rates of dikegulac also significantly reduced growth but not until after the second trimming and lasted until the end of the study.

All flurprimidol treatments and high rates of cimectacarb caused slight foliar necrosis two weeks after treatment but damage was minimal and had grown out after two weeks. Some flower distortion occurred but was not very noticeable. Paclobutrazol and flurprimidol treatments resulted in darker green foliage than untreated areas. The delayed application time after trimming resulted in the wedelia looking slightly overgrown, but was still acceptable for use in the landscape.

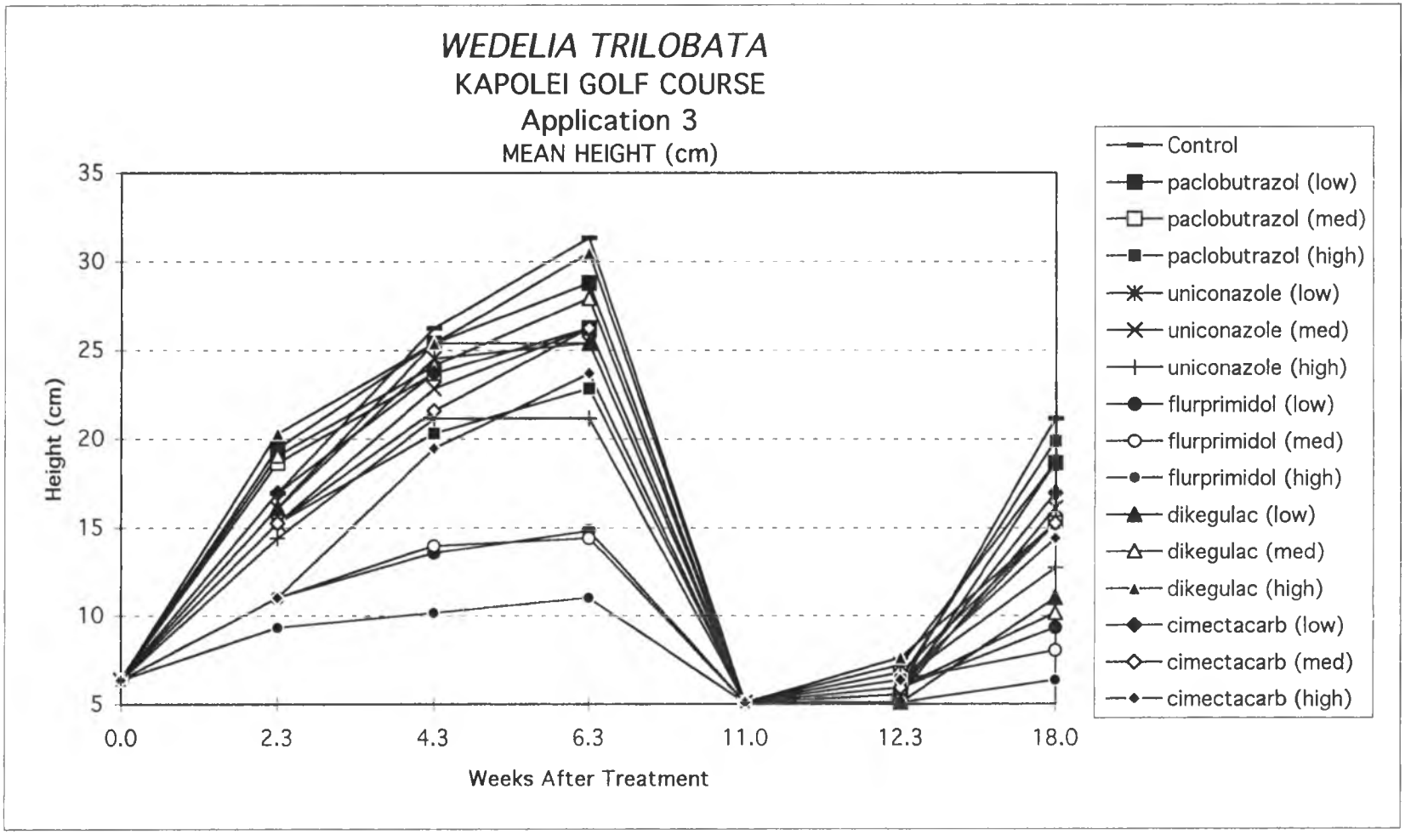
DISCUSSION

Study 1:

Evolvulus glomeratus: All growth regulator application caused some decrease in growth over control, although not always statistically significant. Neither treatments of and uniconazole would be feasible to use in the landscape due to their short length of controlling growth and higher rates would increase the amount of phytotoxicity. Paclobutrazol and flurprimidol seemed to show the most promise due to their length of control, especially flurprimidol. Growth was controlled for 10 weeks, which could eliminate 2 to 4 trimming periods, with relatively minimal foliar damage.

Wedelia trilobata: All growth regulator treatments caused a reduction in growth over that of the control within 1 week after treatment and lasted

Fig. 3.5: Mean height (cm) of *Wedelia trilobata* at Kapolei Golf Course, Oahu, Hawai'i.
Application 3: Growth regulator treatment five weeks after mowing.
Plants were trimmed a second time at week 11.



throughout the study, although not all treatments were statistically significant. All application rates of flurprimdol and paclobutrazol caused the greatest amount of growth regulation with little phytotoxicity. High rates of cimectacarb also resulted in substantial growth reduction but also caused a decrease in flowering. In some landscape situations, such as residential and recreational areas, this may be an additional benefit due to the reduction of bees that are attracted to the flowers.

Study 2:

Only the flurprimidol treatments caused enough growth reduction to make use of growth regulators feasible. High rates of cimectacarb caused substantial growth reduction, but not for a long enough period to make it worth the expense. High rates of flurprimidol controlled growth for up to 3 months, resulting in the elimination of 3 to 6 trimmings, with minimal foliar damage. Optimal application time seemed to be 3 weeks after trimming. This time period allowed the wedelia to recover from the trimming enough to be aesthetic in appearance without becoming overgrown. Application timing would vary at other sites, depending on growth rates.

CHAPTER IV

SUMMARY

A number of commonly grown groundcovers in Hawai'i were treated at various rates with gibberellin biosynthesis inhibitors. Treatments were at varying rates and applied as foliar sprays and soil drenches. All treatments showed some growth regulating effects. As expected, higher rates had greater growth control than lower rates. Drench applications retarded growth greater than foliar spray applications. High rates of some treatments caused phytotoxic damage, at times severely. Growth retarding effects and phytotoxicity varied by plant species.

In container studies, paclobutrazol and flurprimidol had the greatest control over plant growth for all species treated. High rates caused foliar damage, especially to *Cuphea hyssopifolia*. Dikegulac showed some growth reduction on most species, but resulted in the Cuphea having a nice, compact growth with numerous flowers.

In a landscape setting, flurprimidol seemed to have the greatest reduction in growth for any length of time, especially on *Wedelia trilobata*. Application timing was best at three weeks after mowing. There was little phytotoxic damage on the Wedelia, and was at acceptable levels, even at high rates. Flurprimidol also effectively controlled *Evolvulus glomeratus* in the

landscape at low rates. Higher rates caused foliar damage, but it was no longer apparent after 5 weeks.

Flurprimidol and paclobutrazol appear to have the most potential for use in the landscape. At low rates, both are effective at reducing growth. Growth is reduced for a long enough period of time to limit the number applications. Other retardants controlled growth, but would require more frequent applications and at higher rates, limiting their feasibility as landscape maintenance tools.

The use of growth regulators in the landscape has great potential. With proper application methods and rates, they could greatly reduce the labor required to maintain residential and commercial landscapes. This would result in cost savings for landscape maintenance firms without a reduction in aesthetics.

Myoporum spp. 'South Coast'

12/5/1993

Source	df	SS	MS	F	F .05	F .01
Treatment	6	150.94	25.16	1.50	ns	ns
Rep	4	111.94	27.98	1.67	ns	ns
Error	24	401.93	16.75			
TOTAL	34	664.81				

12/15/1993

Source	df	SS	MS	F	F .05	F .01
Treatment	6	121.29	20.22	0.85	ns	ns
Rep	4	108.11	27.03	1.14	ns	ns
Error	24	569.95	23.75			
TOTAL	34	799.35				

1/12/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	117.70	19.62	0.61	ns	ns
Rep	4	150.41	37.60	1.16	ns	ns
Error	24	775.39	32.31			
TOTAL	34	1043.50				

1/23/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	172.48	28.75	1.74	ns	ns
Rep	4	5.51	1.38	0.08	ns	ns
Error	24	396.93	16.54			
TOTAL	34	574.92				

2/7/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	794.01	132.33	3.60	*	ns
Rep	4	271.15	67.79	1.85	ns	ns
Error	24	881.10	36.71			
TOTAL	34	1946.26				

Table A.1: Analysis of variance for the effects of growth regulators on height of *Myoporum 'South Coast'* . Greenhouse study no. 1 (Chap. II)

12/5/93		12/15/93		1/12/94		1/23/94		2/7/94	
Pac 2X	24.38 a[z]	Pac 2X	24.89 a	Pac 1X	26.92 a	Control	16.50 a	Control	38.35 a
Unicon 2X	24.13 a	Unicon 2X	24.64 a	Control	26.67 a	Pac 1X	12.30 a	Unicon 2X	35.56 a
Control	22.35 a	Control	24.38 a	Unicon 2X	26.42 a	Pac 2X	11.70 a	Pac 1X	35.31 a
Unicon 1X	21.08 a	Unicon 1X	24.13 a	Pac 2X	26.42 a	Unicon 2X	11.40 a	Pac 2X	32.77 ab
Flur 1X	20.83 a	Flur 1X	22.35 a	Unicon 1X	25.40 a	Unicon 1X	11.10 a	Unicon 1X	32.77 ab
Pac 1X	19.69 a	Pac 1X	22.10 a	Flur 1X	24.38 a	Flur 1X	10.40 a	Flur 1X	28.70 ab
Flur 2X	18.29 a	Flur 2X	19.30 a	Flur 2X	21.34 a	Flur 2X	8.70 a	Flur 2X	22.86 b

Table A.2 : Mean heights (cm) by date of *Myoporum* spp. 'South Coast' treated with growth regulators on November 18, 1993.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Myoporum spp. 'Davis'

12/5/1993

Source	df	SS	MS	F	F .05	F .01
Treatment	6	239.10	39.85	1.49	ns	ns
Rep	4	28.16	7.04	0.26	ns	ns
Error	24	642.81	26.78			
TOTAL	34	910.07				

12/15/1993

Source	df	SS	MS	F	F .05	F .01
Treatment	6	275.39	45.90	1.48	ns	ns
Rep	4	47.28	11.82	0.38	ns	ns
Error	24	743.04	30.96			
TOTAL	34	1065.71				

1/12/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	539.35	89.89	2.36	ns	ns
Rep	4	124.70	31.18	0.82	ns	ns
Error	24	915.94	38.16			
TOTAL	34	1580.00				

1/23/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	1050.60	175.10	4.67	*	**
Rep	4	88.76	22.19	0.59	ns	ns
Error	24	899.63	37.48			
TOTAL	34	2038.98				

2/7/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	1814.74	302.46	9.25	*	**
Rep	4	113.09	28.27	0.87	ns	ns
Error	24	784.33	32.68			
TOTAL	34	2712.16				

Table A.3: Analysis of variance for the effects of growth regulators on height of *Myoporum 'Davis'* . Greenhouse study no. 1 (Chap. II)

12/5/93		12/15/93		1/12/94		1/23/94		2/7/94	
Unicon 1X	28.96 a[z]	Unicon 1X	29.72 a	Unicon 1X	34.80 a	Unicon 1X	40.13 a	Unicon 1X	46.0 a
Control	28.19 a	Control	29.46 a	Control	33.27 a	Control	39.62 a	Control	45.7 a
Unicon 2X	24.89 a	Unicon 2X	28.19 a	Unicon 2X	32.00 a	Unicon 2X	35.05 ab	Unicon 2X	38.9 ab
Pac 2X	24.51 a	Pac 2X	24.89 a	Pac 2X	26.67 a	Flur 1X	28.70 ab	Flur 1X	32.5 b
Flur 2X	23.62 a	Flur 2X	24.13 a	Flur 2X	25.91 a	Pac 2X	28.19 ab	Pac 1X	29.5 b
Flur 1X	22.86 a	Flur 1X	22.86 a	Flur 1X	25.40 a	Flur 2X	26.92 b	Pac 2X	28.7 b
Pac 1X	21.08 a	Pac 1X	22.86 a	Pac 1X	24.64 a	Pac 1X	26.92 b	Flur 2X	28.7 b

Table A.4: Mean heights (cm) by date of *Myoporum* spp. 'Davis' treated with growth regulators on November 18, 1993.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Evolvulus glomeratus

12/5/1993

Source	df	SS	MS	F	F .05	F .01
Treatment	6	216.27	36.04	2.69	*	ns
Rep	4	42.44	10.61	0.79	ns	ns
Error	24	321.75	13.41			
TOTAL	34	580.46				

12/15/1993

Source	df	SS	MS	F	F .05	F .01
Treatment	6	390.78	65.13	4.56	*	**
Rep	4	34.56	8.64	0.60	ns	ns
Error	24	342.86	14.29			
TOTAL	34	768.20				

1/12/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	636.77	106.13	6.43	*	**
Rep	4	44.70	11.18	0.68	ns	ns
Error	24	395.94	16.50			
TOTAL	34	1077.42				

1/23/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	1310.87	218.48	11.27	*	**
Rep	4	45.81	11.45	0.59	ns	ns
Error	24	465.16	19.38			
TOTAL	34	1821.84				

2/7/1994

Source	df	SS	MS	F	F .05	F .01
Treatment	6	2163.22	360.54	17.95	*	**
Rep	4	80.64	20.16	1.00	ns	ns
Error	24	481.93	20.08			
TOTAL	34	2725.80				

Table A.5: Analysis of variance for the effects of growth regulators on height of *Evolvulus glomeratus* . Greenhouse study no. 1 (Chap. II)

12/5/93		12/15/93		1/12/94		1/23/94		2/7/94	
control	29.34 a[z]	Control	30.99 a	Control	33.78 a	Control	38.86 a	Control	43.69 a
Unicon 1X	27.43 ab	Unicon 1X	29.97 a	Unicon 2X	32.51 ab	Unicon 1X	36.07 a	Unicon 1X	40.64 a
Unicon 2X	27.31 ab	Unicon 2X	29.46 ab	Unicon 1X	32.00 ab	Unicon 2X	34.54 a	Unicon 2X	37.34 a
Pac 1X	25.27 ab	Pac 1X	25.40 ab	Pac 1X	25.40 bc	Pac 1X	25.40 b	Flur 1X	26.42 b
Flur 1X	23.88 ab	Flur 1X	24.38 ab	Flur 1X	24.64 bc	Flur 1X	25.15 b	Pac 1X	25.91 b
Flur 2X	23.37 ab	Flur 2X	23.37 ab	Flur 2X	24.38 bc	Flur 2X	24.38 b	Flur 2X	24.89 b
Pac 2X	21.72 b	Pac 2X	21.84 b	Pac 2X	22.86 c	Pac 2X	22.86 b	Pac 2X	23.37 b

Table A.6: Mean heights (cm) by date of *Evolvulus glomeratus* treated with growth regulators on November 18, 1993.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Cuphea hyssopifolia (green stemmed)

3/6/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	144.58	12.05	17.32	*	**
Rep	3	1.71	0.57	0.82	ns	ns
Error	36	25.04	0.70			
Total	51	171.33				

3/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	199.02	16.58	31.97	*	**
Rep	3	1.51	0.50	0.97	ns	ns
Error	36	18.67	0.52			
Total	51	219.21				

4/2/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	336.33	28.03	33.31	*	**
Rep	3	0.90	0.30	0.36	ns	ns
Error	36	30.29	0.84			
Total	51	367.51				

4/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	489.08	40.76	31.92	*	**
Rep	3	1.04	0.35	0.27	ns	ns
Error	36	45.96	1.28			
Total	51	536.08				

4/30/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	680.31	56.69	41.29	*	**
Rep	3	1.08	0.36	0.26	ns	ns
Error	36	49.42	1.37			
Total	51	730.81				

Table A.7: Analysis of variance for the effects of growth regulators on height of *Cuphea hyssopifolia* (green stemmed).
Greenhouse study no. 2 (Chap. II)

3/6/1994		
Control	16.50	a[z]
Emb 3X spry	13.50	b
Emb 1X spry	13.25	b
Sum 1X drnch	12.88	bc
Pac 1X spry	12.38	bcd
Cut 1X spry	11.13	bcd
Cut 3X spry	11.00	bcd
Sum 3X drnch	11.00	bcd
Pac 1X drnch	11.00	bcd
Cut 3X drnch	10.88	bcd
Pac 3X spry	10.75	bcd
Cut 1X drnch	10.75	bcd
Pac 3X drnch	10.25	bcd

3/19/1994		
Control	17.50	a
Emb 3X spry	14.25	b
Emb 1X spry	14.13	b
Sum 1X drnch	13.00	bc
Pac 1X spry	12.38	bcd
Cut 3X spry	11.25	bcde
Cut 1X spry	11.13	bcde
Pac 3X spry	11.13	bcde
Cut 3X drnch	11.00	bcde
Sum 3X drnch	11.00	bcde
Pac 1X drnch	11.00	bcde
Cut 1X drnch	10.88	bcde
Pac 3X drnch	10.25	bcde

4/2/1994		
Control	19.75	a
Emb 3X spry	15.50	b
Emb 1X spry	15.38	bc
Sum 1X drnch	13.13	bcd
Pac 1X spry	13.00	bcd
Pac 3X spry	11.88	bcd
Cut 1X spry	11.75	bcd
Cut 3X spry	11.75	bcd
Pac 1X drnch	11.25	bcd
Sum 3X drnch	11.13	bcd
Sum 3X drnch	11.13	bcd
Cut 1X drnch	10.88	bcd
Cut 1X drnch	10.88	bcd

4/19/1994		
Control	21.00	a
Emb 3X spry	17.50	b
Emb 1X spry	16.50	b
Sum 1X drnch	13.25	c
Pac 1X spry	13.13	c
Pac 3X spry	11.88	cd
Cut 1X spry	11.75	cd
Cut 3X spry	11.75	cd
Sum 3X drnch	11.38	cd
Pac 1X drnch	11.25	cd
Cut 3X drnch	11.00	cd
Cut 1X drnch	10.88	cd
Pac 3X drnch	10.25	cd

4/30/1994		
Control	23.25	a
Emb 3X spry	18.00	b
Emb 1X spry	17.75	b
Pac 1X spry	13.38	c
Sum 1X drnch	13.38	c
Pac 3X spry	12.13	c
Cut 1X spry	11.75	c
Cut 3X spry	11.75	c
Sum 3X drnch	11.75	c
Pac 1X drnch	11.25	c
Cut 3X drnch	11.00	c
Cut 1X drnch	10.88	c
Pac 3X drnch	10.75	c

Table A.8: Mean heights (cm) by date of *Cuphea hyssopifolia* (green stemmed) treated with growth regulators on January 25, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Cuphea hyssopifolia (red stemmed)

2/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	108.67	9.06	20.50	*	**
Rep	3	1.78	0.59	1.35	ns	ns
Error	36	15.90	0.44			
Total	51	126.36				

3/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	179.94	15.00	28.10	*	**
Rep	3	1.48	0.49	0.92	ns	ns
Error	36	19.21	0.53			
Total	51	200.63				

4/2/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	221.86	18.49	31.48	*	**
Rep	3	1.67	0.56	0.95	ns	ns
Error	36	21.14	0.59			
Total	51	244.67				

4/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	342.13	28.51	44.20	*	**
Rep	3	1.90	0.63	0.98	ns	ns
Error	36	23.22	0.65			
Total	51	367.25				

4/30/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	12	455.95	38.00	37.70	*	**
Rep	3	3.10	1.03	1.02	ns	ns
Error	36	36.28	1.01			
Total	51	495.33				

Table A.9: Analysis of variance for the effects of growth regulators on height of *Cuphea hyssopifolia* (red stemmed). Greenhouse study no. 2 (Chap. II)

2/19/1994		
Control	15.00	a[z]
Sum 1/2X spry	13.75	ab
Emb 1X spry	12.75	b
Sum 1X spry	12.00	bc
Emb 3X spry	12.00	bc
Sum 3X drnch	11.50	bcd
Sum 1X drnch	11.25	bcd
Cut 1X spry	11.00	bcd
Cut 1X drnch	10.50	bcd
Pac 1X drnch	10.13	bcd
Cut 3X spry	10.25	bcd
Cut 3X drnch	10.25	bcd
Pac 3X drnch	10.25	bcd

3/19/1994		
Control	16.25	a
Pac 1X spry	14.50	ab
Emb 1X spry	13.38	bc
Emb 3X spry	13.38	bc
Pac 3X spry	12.63	bcd
Sum 3X drnch	11.50	bcde
Sum 1X drnch	11.25	bcde
Cut 1X spry	11.13	bcde
Cut 1X drnch	10.50	bcde
Cut 3X spry	10.25	bcde
Pac 1X drnch	10.25	bcde
Pac 3X drnch	10.25	bcde
Cut 3X drnch	10.13	bcde

4/2/1994		
Control	16.63	a
Sum 1/2X spry	15.25	ab
Emb 1X spry	14.25	b
Emb 3X spry	14.00	b
Sum 1X spry	13.63	bc
Sum 3X drnch	11.88	cd
Sum 1X drnch	11.63	d
Cut 1X spry	11.38	d
Cut 1X drnch	10.63	d
Cut 3X drnch	10.50	d
Pac 1X drnch	10.38	d
Cut 3X spry	10.25	d
Pac 3X drnch	10.25	d

4/19/1994		
Control	18.25	a
Sum 1/2X spry	16.00	b
Emb 1X spry	15.38	bc
Emb 3X spry	15.13	bc
Sum 1X spry	13.88	cd
Sum 3X drnch	12.00	de
Sum 1X drnch	11.63	e
Cut 1X spry	11.38	e
Cut 1X drnch	10.75	e
Cut 3X drnch	10.50	e
Pac 1X drnch	10.38	e
Pac 3X drnch	10.25	e
Cut 3X spry	10.25	e

4/30/1994		
Control	19.00	a
Emb 1X spry	17.38	a
Emb 3X spry	17.38	a
Sum 1/2X spry	16.50	ab
Sum 1X spry	14.50	bc
Sum 1X drnch	12.25	cd
Sum 3X drnch	12.00	cd
Cut 1X spry	11.63	cd
Cut 1X drnch	11.25	cd
Cut 3X spry	11.13	cd
Cut 3X drnch	10.88	cd
Pac 1X drnch	10.63	cd
Pac 3X drnch	10.25	cd

Table A.10: Mean heights (cm) by date of *Cuphea hyssopifolia* (red stemmed) treated with growth regulators on January 25, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Evolvulus glomeratus

2/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	8.59	0.61	4.59	*	**
Rep	3	0.61	0.20	1.52	ns	ns
Error	42	5.61	0.13			
Total	59	14.81				

3/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	425.53	30.39	24.86	*	**
Rep	3	5.85	1.95	1.59	ns	ns
Error	42	51.34	1.22			
Total	59	482.71				

4/2/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	1042.61	74.47	38.43	*	**
Rep	3	2.55	0.85	0.44	ns	ns
Error	42	81.39	1.94			
Total	59	1126.55				

4/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	2089.06	149.22	56.29	*	**
Rep	3	4.35	1.45	0.55	ns	ns
Error	42	111.34	2.65			
Total	59	2204.75				

Table A.11: Analysis of variance for the effects of growth regulators on height of *Evolvulus glomeratus* . Greenhouse study no. 2 (Chap. II)

2/19/1994		3/19/1994		4/2/1994		4/19/1994	
Control	11.38 a[z]	Control	18.88 a	Control	23.00 a	Sum 1/2X spry	25.75 a
Cut 1X spry	11.25 ab	Sum 1/2X spry	17.13 ab	Sum 1/2X spry	21.25 ab	Control	25.25 a
Pac 1X spry	11.25 ab	Pac 1X spry	16.63 abc	Pac 1X spry	19.25 bc	Emb 1X spry	24.25 a
Emb 3X spry	11.00 abc	Emb 1X spry	15.00 bcd	Sum 1X spry	19.00 bc	Sum 1X spry	24.00 a
Pac 3X spry	10.81 abc	Sum 1X spry	13.88 cde	Emb 1X spry	17.63 cd	Pac 1X spry	21.88 a
Sum 1X spry	10.75 abc	Emb 3X spry	13.75 def	Emb 3X spry	17.13 cd	Emb 3X spry	21.75 a
Emb 1X spry	10.75 abc	Pac 3X spry	12.75 def	Pac 3X spry	15.00 de	Pac 3X spry	15.25 b
Sum 1X drnch	10.75 abc	Cut 1X spry	11.88 ef	Cut 1X spry	13.00 ef	Cut 1X spry	14.38 bc
Sum 3X drnch	10.69 abc	Sum 1X drnch	11.38 ef	Sum 1X drnch	11.88 ef	Cut 3X spry	12.63 bc
Cut 3X spry	10.63 abc	Cut 3X spry	10.88 f	Cut 3X spry	11.38 f	Sum 1X drnch	12.25 bc
Sum 1/2X spry	10.63 abc	Sum 3X drnch	10.88 f	Cut 1X drnch	11.25 f	Cut 1X drnch	12.00 bc
Cut 1X drnch	10.38 bc	Cut 1X drnch	10.88 f	Cut 3X drnch	11.00 f	Cut 3X drnch	11.13 bc
Cut 3X drnch	10.25 c	Cut 3X drnch	10.75 f	Sum 3X drnch	11.00 f	Sum 3X drnch	11.00 bc
Pac 1X drnch	10.13 c	Pac 3X drnch	10.50 f	Pac 3X drnch	10.75 f	Pac 3X drnch	10.75 c
Pac 3X drnch	10.13 c	Pac 1X drnch	10.25 f	Pac 1X drnch	10.38 f	Pac 1X drnch	10.38 c

Table A.12: Mean heights (cm) by date of *Evolvulus glomeratus* treated with growth regulators on January 25, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Liriope muscari

3/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	6	355.17	59.20	20.37	*	**
Rep	4	4.74	1.19	0.41	ns	ns
Error	24	69.76	2.91			
Total	34	429.67				

4/2/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	6	667.67	111.28	16.32	*	**
Rep	4	24.19	6.05	0.89	ns	ns
Error	24	163.61	6.82			
Total	34	855.47				

4/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	6	965.79	160.96	21.87	*	**
Rep	4	12.76	3.19	0.43	ns	ns
Error	24	176.64	7.36			
Total	34	1155.19				

4/30/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	6	1436.27	239.38	27.39	*	**
Rep	4	32.57	8.14	0.93	ns	ns
Error	24	209.73	8.74			
Total	34	1678.57				

Table A.13: Analysis of variance for the effects of growth regulators on height of *Liriope muscari* . Greenhouse study no. 2 (Chap. II)

3/19/1994		4/2/1994		4/19/1994		4/30/1994	
Control	19.80 a[z]	Control	23.60 a	Control	25.20 a	Control	27.80 a
Prm 8X spry	14.50 b	Prm 8X spry	18.30 ab	Emb 3X spry	21.90 b	Emb 3X spry	25.20 b
Prm 4X spry	13.00 bc	Prm 4X spry	14.60 bc	Prm 8X spry	20.20 bc	Prm 8X spry	22.80 bc
Emb 3X spry	11.70 bc	Emb 3X spry	14.60 bc	Emb 1X spry	17.00 bc	Emb 1X spry	21.20 bc
Emb 1X spry	10.70 c	Emb 1X spry	13.20 bc	Prm 4X spry	16.00 bc	Prm 4X spry	18.50 c
Cut 1X spry	10.20 c	Cut 1X spry	10.30 c	Cut 1X spry	10.30 d	Cut 1X spry	10.30 d
Cut 3X spry	10.20 c	Cut 3X spry	10.20 c	Cut 3X spry	10.20 d	Cut 3X spry	10.20 d

Table A.14: Mean heights (cm) by date of *Liriope muscari* treated with growth regulators on January 25, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Wedelia trilobata

2/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	638.75	42.58	3.51	*	**
Rep	4	38.89	9.72	0.80	ns	ns
Error	60	728.91	12.15			
Total	79	1406.55				

3/6/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	3433.79	228.92	7.00	*	*
Rep	4	114.05	28.51	0.87	ns	ns
Error	60	1961.15	32.69			
Total	79	5508.99				

3/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	8110.35	540.69	8.13	*	**
Rep	4	480.32	120.08	1.81	ns	ns
Error	60	3988.08	66.47			
Total	79	12578.75				

4/2/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	28544.79	1902.99	10.72	*	**
Rep	4	976.70	244.18	1.38	ns	ns
Error	60	10646.90	177.45			
Total	79	40168.39				

4/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	53165.55	3544.37	15.15	*	**
Rep	4	3334.45	833.61	3.56	ns	ns
Error	60	14037.95	233.97			
Total	79	70537.95				

6/10/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	4855.89	323.73	1.51	ns	ns
Rep	4	1269.32	317.33	1.48	ns	ns
Error	60	12824.68	213.74			
Total	79	18949.89				

Table A.15: Analysis of variance for the effects of growth regulators on height of *Wedelia trilobata* . Greenhouse study no. 2 (Chap. II)

2/19/1994		3/6/1994		3/19/1994	
Control	42.40 a[z]	Control	42.40 a	Control	59.00 a
Pac 1X spry	37.80 ab	Pac 1X spry	37.80 ab	Sum 1X spry	51.20 ab
Sum 1X spry	37.20 ab	Sum 1X spry	37.20 abc	Pac 1X spry	50.80 ab
Sum 1/2X spry	33.00 abc	Sum 1/2X spry	33.00 abcd	Sum 1X drnch	47.10 abc
Sum 3X drnch	33.00 abc	Pac 3X spry	32.20 abcd	Sum 1/2X spry	45.80 abcd
Pac 3X spry	32.20 abc	Sum 1X drnch	32.00 abcd	Pac 3X spry	44.20 abcde
Sum 1X drnch	32.00 abc	Emb 1X spry	30.40 abcd	Emb 1X spry	43.20 abcdef
Emb 1X spry	30.40 bc	Emb 3X spry	28.40 bcd	Sum 3X drnch	42.75 abcdefg
Emb 3X spry	28.40 bc	Cut 1X drnch	28.00 bcd	Emb 3X spry	40.40 bcdefg
Cut 1X drnch	28.00 bc	Pac 3X drnch	27.60 bcd	Pac 3X drnch	33.60 cdefg
Pac 3X drnch	27.60 bc	Sum 3X drnch	25.00 bcd	Cut 1X drnch	31.80 defg
Cut 1X spry	25.00 c	Cut 1X spry	25.00 bcd	Cut 1X spry	30.60 efg
Prim 8X spry	24.60 c	Prim 8X spry	24.60 cd	Prim 8X spry	28.80 fg
Pac 1X drnch	24.20 c	Pac 1X drnch	24.20 d	Cut 3X drnch	27.20 g
Cut 3X drnch	23.60 c	Cut 3X drnch	23.60 d	Cut 3X spry	25.60 g
Cut 3X spry	22.80 c	Cut 3X spry	22.80 d	Pac 1X drnch	25.60 g

4/2/1994		4/19/1994		6/10/1994	
Control	84.00 a	Control	99.80 a	Emb 3X spry	93.00 a
Pac 1X spry	70.80 ab	Emb 1X spry	93.80 ab	Sum 1X spry	92.00 a
Sum 3X drnch	70.60 ab	Pac 1X spry	93.60 ab	Sum 1/2X spry	90.00 a
Sum 1X drnch	70.00 ab	Sum 1/2X spry	91.20 ab	Pac 3X spry	89.80 a
Sum 1X spry	68.60 ab	Sum 1X spry	85.00 ab	Cut 3X spry	88.60 a
Emb 1X spry	66.60 abc	Pac 3X spry	83.80 ab	Prim 8X spry	85.80 a
Pac 3X spry	66.20 abc	Sum 3X drnch	83.40 ab	Cut 1X drnch	85.40 a
Sum 1/2X spry	60.80 abc	Sum 1X drnch	81.40 abc	Emb 1X spry	85.00 a
Emb 3X spry	55.80 abcd	Emb 3X spry	71.60 abcd	Control	84.20 a
Pac 3X drnch	49.60 bcde	Pac 3X drnch	62.60 bcde	Pac 1X spry	82.60 a
Cut 1X spry	37.20 cde	Cut 1X spry	48.60 cdef	Sum 1X drnch	80.00 a
Cut 1X drnch	36.80 cde	Cut 1X drnch	37.80 def	Sum 3X drnch	78.20 a
Prim 8X spry	30.80 de	Prim 8X spry	35.40 ef	Pac 3X drnch	76.40 a
Cut 3X drnch	26.80 de	Cut 3X drnch	32.60 ef	Cut 3X drnch	75.00 a
Pac 1X drnch	26.40 de	Pac 1X drnch	29.80 ef	Cut 1X spry	74.40 a
Cut 3X spry	25.60 f	Cut 3X spry	26.00 f	Pac 1X drnch	62.20 a

Table A.16: Mean heights (cm) by date of *Wedelia trilobat* treated with growth regulators on January 25, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Evolvulus glomeratus

9/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	0.00	0.00	0.00	ns	ns
Rep	2	0.00	0.00	0.00	ns	ns
Error	22	0.00	0.00			
TOTAL	35	0.00				

9/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	0.80	0.10	0.60	ns	ns
Rep	2	0.20	0.10	0.70	ns	ns
Error	22	2.50	0.10			
TOTAL	35	3.40				

10/3/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	23.00	2.10	5.80	*	**
Rep	2	1.70	0.90	2.30	ns	ns
Error	22	8.00	0.40			
TOTAL	35	32.70				

10/17/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	121.30	11.00	34.80	*	**
Rep	2	3.00	1.50	4.70	*	ns
Error	22	7.00	0.30			
TOTAL	35	131.30				

10/31/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	452.50	41.10	31.50	*	**
Rep	2	1.60	0.80	0.60	ns	ns
Error	22	28.70	1.30			
TOTAL	35	482.90				

11/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	935.40	85.00	37.30	*	**
Rep	2	0.60	0.30	0.10	ns	ns
Error	22	50.20	2.30			
TOTAL	35	986.20				

11/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	1841.40	167.40	36.30	*	**
Rep	2	11.50	5.70	1.20	ns	ns
Error	22	101.40	4.60			
TOTAL	35	1954.30				

12/12/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	11	3048.80	277.20	38.20	*	**
Rep	2	10.80	5.40	0.70	ns	ns
Error	22	159.60	7.30			
TOTAL	35	3219.20				

Table A.17: Analysis of variance for the effects of growth regulators on height of *Evolvulus glomeratus* . Field study no. 1 (Chap. III)

9/14/1994		
Control	30.48	a
Paclobutrazol low	30.48	a
Paclobutrazol med.	30.48	a
Paclobutrazol high	30.48	a
Uniconazole low	30.48	a
Uniconazole high	30.48	a
Flurprimidol low	30.48	a
Flurprimidol high	30.48	a
Dikegulac low	30.48	a
Dikegulac high	30.48	a
Cimectacarb low	30.48	a
Cimectacarb high	30.48	a

9/19/1994		
Control	30.90	a
Paclobutrazol med.	30.90	a
Paclobutrazol high	30.90	a
Dikegulac low	30.90	a
Uniconazole low	30.69	a
Flurprimidol low	30.69	a
Flurprimidol high	30.69	a
Dikegulac high	30.69	a
Cimectacarb low	30.69	a
Cimectacarb high	30.69	a
Paclobutrazol low	30.48	a
Uniconazole high	30.48	a

10/3/1994		
Control	34.5	a
Dikegulac low	34.08	ab
Uniconazole low	33.87	ab
Uniconazole high	33.87	ab
Paclobutrazol low	33.66	ab
Cimectacarb low	33.66	ab
Paclobutrazol med.	33.44	ab
Dikegulac high	33.44	ab
Flurprimidol low	32.81	abc
Paclobutrazol high	32.60	bc
Cimectacarb high	32.39	bc
Flurprimidol high	31.54	c

10/17/1994		
Control	37.68	a
Dikegulac low	37.47	ab
Uniconazole low	37.25	ab
Dikegulac high	35.98	bc
Paclobutrazol low	35.35	c
Uniconazole high	35.14	c
Cimectacarb low	35.14	c
Paclobutrazol med.	34.50	cd
Flurprimidol low	33.44	d
Cimectacarbh	33.44	d
Paclobutrazol high	33.02	de
Flurprimidol high	31.54	e

10/31/1994		
Control	42.76	a
Dikegulac low	42.12	a
Uniconazole low	41.28	ab
Dikegulac high	40.22	ab
Uniconazole high	39.79	abc
Cimectacarb low	38.52	bcd
Paclobutrazol low	36.41	cde
Cimectacarb high	35.77	de
Paclobutrazol med.	35.35	de
Flurprimidol low	33.87	ef
Paclobutrazol high	33.44	ef
Flurprimidol high	31.54	f

11/14/1994		
Control	48.05	a
Dikegulac low	46.99	a
Dikegulac high	46.36	a
Uniconazole low	46.14	a
Cimectacarb low	13.82	ab
Uniconazole high	43.60	ab
Cimectacarb high	40.43	bc
Paclobutrazol low	39.58	bcd
Paclobutrazol med.	38.31	cd
Paclobutrazol high	35.35	cde
Flurprimidol low	35.15	cde
Flurprimidol high	31.96	e

11/28/1994		
Dikegulac low	57.15	a
Dikegulac high	53.76	a
Control	53.55	a
Cimectacarb low	53.13	ab
Uniconazole low	51.86	abc
Uniconazole high	51.01	abc
Cimectacarb high	46.99	bcd
Paclobutrazol low	45.93	cd
Paclobutrazol med.	43.60	de
Flurprimidol low	38.52	ef
Paclobutrazol high	37.89	ef
Flurprimidol high	33.66	f

12/12/1994		
Dikegulac low	64.77	a
Dikegulac high	61.38	ab
Control	61.38	ab
Uniconazole low	59.48	ab
Cimectacarb low	58.00	abc
Uniconazole high	56.94	abc
Paclobutrazol low	55.46	bc
Cimectacarbh	53.55	bc
Paclobutrazol med.	50.38	cd
Paclobutrazol high	42.55	de
Flurprimidol low	39.79	ef
Flurprimidol high	34.08	f

Table A.18: Mean heights (cm) by date of *Evolvulus glomeratus* treated with growth regulators on September 14, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Wedelia trilobata

9/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	839.03	59.93	62.04	*	**
Rep	3	2.11	0.70	0.73	ns	ns
Error	42	40.57	0.97			
TOTAL	59	881.71				

9/19/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	3.38	0.24	3.72	*	**
Rep	3	0.15	0.05	0.77	ns	ns
Error	42	2.72	0.06			
TOTAL	59	6.25				

10/3/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	72.22	5.16	16.74	*	**
Rep	3	0.93	0.31	1.01	ns	ns
Error	42	12.94	0.31			
TOTAL	59	86.10				

10/17/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	287.75	20.55	28.20	*	**
Rep	3	0.88	0.29	0.40	ns	ns
Error	42	30.62	0.73			
TOTAL	59	319.25				

10/31/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	839.03	59.93	62.04	*	**
Rep	3	2.11	0.70	0.73	ns	ns
Error	42	40.57	0.97			
TOTAL	59	881.71				

11/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	1648.23	117.73	133.13	*	**
Rep	3	3.23	1.08	1.22	ns	ns
Error	42	37.14	0.88			
TOTAL	59	1688.60				

11/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	2452.36	175.17	198.08	*	**
Rep	3	3.23	1.08	1.22	ns	ns
Error	42	37.14	0.88			
TOTAL	59	2492.73				

12/12/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	14	3521.35	251.53	165.97	*	**
Rep	3	2.35	0.78	0.52	ns	ns
Error	42	63.65	1.52			
TOTAL	59	3587.35				

Table A.19: Analysis of variance for the effects of growth regulators on height of *Wedelia trilobata* . Field study no. 1 (Chap. III)

9/14/94		9/19/94		10/3/94		10/17/94	
Control	31.88 a[z]	Control	18.75 a	Primo lo	21.63 a	Control	25.38 a
Emb lo	30.38 ab	Pac lo	18.63 ab	Emb lo	21.50 a	Emb lo	25.25 a
Sum lo	30.00 ab	Sum lo	18.50 ab	Control	21.38 ab	Primo lo	25.00 ab
Primo lo	29.63 ab	Emb lo	18.50 ab	Sum lo	21.25 ab	Sum lo	24.88 ab
Sum med	28.38 bc	Sum med	18.38 ab	Emb hi	21.25 ab	Emb hi	24.25 abc
Emb hi	28.38 bc	Emb hi	18.25 ab	Sum med	21.13 abc	Sum hi	24.13 abc
Sum hi	28.00 bc	Primo lo	18.25 ab	Sum hi	20.88 abcd	Sum med	23.88 abc
Primo med	26.50 cd	Pac med	18.13 ab	Pac lo	20.38 abcd	Primo med	23.38 abcd
Pac lo	25.63 d	Sum hi	18.13 ab	Primo med	20.38 abcd	Pac lo	22.75 bcd
Primo hi	25.38 d	Cut lo	18.13 ab	Primo hi	20.00 bcde	Primo hi	22.25 cd
Pac med	24.50 d	Primo med	18.13 ab	Cut lo	19.75 cdef	Cut lo	21.50 de
Cut lo	24.25 de	Pac hi	18.00 b	Pac med	19.50 defg	Pac med	21.13 de
Pac hi	21.75 ef	Cut med	18.00 b	Cut med	18.75 efg	Cut med	19.50 ef
Cut med	19.88 f	Cut hi	18.00 b	Pac hi	18.50 fg	Pac hi	19.38 ef
Cut hi	18.88 f	Primo hi	18.00 b	Cut hi	18.25 g	Cut hi	18.63 f

10/31/94		11/14/94		11/28/94		12/12/94	
Control	31.88 a	Control	37.75 a	Control	41.50 a	Control	45.88 a
Emb lo	30.38 ab	Sum lo	35.50 ab	Sum lo	40.38 a	Sum lo	45.38 ab
Sum lo	30.00 ab	Emb lo	35.38 abc	Emb lo	39.75 ab	Emb lo	44.25 abc
Primo lo	29.63 ab	Primo lo	34.13 bcd	Primo lo	37.63 bc	Primo lo	43.38 abc
Sum med	28.38 bc	Sum med	33.00 cd	Emb hi	37.00 cd	Emb hi	42.50 bc
Emb hi	28.38 bc	Sum hi	32.75 d	Sum med	36.25 cd	Sum med	41.75 cd
Sum hi	28.00 bc	Emb hi	32.75 d	Sum hi	35.00 de	Sum hi	39.13 d
Primo med	26.50 cd	Primo med	29.63 e	Pac lo	33.75 ef	Pac lo	37.25 de
Pac lo	25.63 d	Pac lo	29.38 e	Primo med	33.50 ef	Primo med	36.13 def
Primo hi	25.38 d	Pac med	28.00 ef	Pac med	31.63 fg	Pac med	35.38 ef
Pac med	24.50 d	Primo hi	27.88 ef	Primo hi	30.25 g	Pac hi	33.25 fg
Cut lo	24.25 de	Cut lo	26.25 fg	Pac hi	26.63 h	Primo hi	31.75 g
Pac hi	21.75 ef	Pac hi	24.38 g	Cut lo	26.25 h	Cut lo	28.38 h
Cut med	19.88 f	Cut med	21.25 h	Cut med	22.63 i	Cut med	24.25 i
Cut hi	18.88 f	Cut hi	19.00 h	Cut hi	19.38 j	Cut hi	19.63 j

Table A.20: Mean heights (cm) by date of *Wedelia trilobata* treated with growth regulators on September 14, 1994.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Wedelia trilobata

8/16/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	77.91	5.19	1.49	ns	ns
Rep	2	115.51	57.76	16.61	*	**
Error	30	104.32	3.48			
TOTAL	47	297.74				

9/7/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	878.83	58.59	2.52	*	ns
Rep	2	1333.72	666.86	28.63	*	**
Error	30	698.78	23.29			
TOTAL	47	2911.33				

9/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	2159.45	143.96	2.17	*	ns
Rep	2	1078.14	539.07	8.13	*	**
Error	30	1989.41	66.31			
TOTAL	47	5227.01				

10/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	3487.58	232.51	3.59	*	**
Rep	2	1350.33	675.17	10.43	*	**
Error	30	1942.37	64.75			
TOTAL	47	6780.28				

10/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	4353.53	290.24	3.68	*	**
Rep	2	1034.59	517.29	6.56	*	**
Error	30	2364.17	78.81			
TOTAL	47	7752.29				

Table A.21: Analysis of variance for the effects of growth regulators applied one day after trimming on height of *Wedelia trilobata* . Field study no. 2 (Chap. III)

8/16/94		9/7/94		9/28/94		10/14/94		10/28/94	
Control	10.67 a[z]	Control	23.67 a	Control	34.31 a	Control	41.49 a	Emb 2X	44.87 a
Sum 4X	9.00 a	Emb 2X	19.67 ab	Prm 8X	30.06 a	Emb 2X	40.64 a	Control	43.18 a
Emb 2X	9.00 a	Prm 2X	19.67 ab	Emb 4X	27.94 a	Prm 4X	37.25 a	Sum 2X	39.79 ab
Prm 2X	9.00 a	Prm 4X	17.00 ab	Sum 2X	24.55 a	Emb 4X	36.41 ab	Emb 1X	38.95 ab
Emb 1X	8.67 a	Sum 1X	16.67 ab	Prm 2X	24.55 a	Prm 8X	36.41 ab	Prm 2X	38.95 ab
Prm 4X	8.67 a	Emb 1X	16.00 ab	Prm 4X	23.67 a	Sum 2X	35.56 ab	Emb 4X	36.41 ab
Emb 4X	8.33 a	Sum 2X	15.33 ab	Emb 2X	21.17 a	Prm 2X	34.77 ab	Prm 4X	38.10 ab
Sum 2X	8.00 a	Emb 4X	14.33 ab	Sum 1X	20.27 a	Pac 1X	32.60 ab	Prm 8X	36.45 ab
Cut 1X	7.67 a	Pac 1X	14.00 ab	Pac 1X	18.63 a	Emb 1X	32.23 ab	Pac 1X	35.98 ab
Sum 1X	7.33 a	Prm 8X	13.67 ab	Sum 4X	17.85 a	Sum 4X	27.94 ab	Sum 1X	29.63 ab
Prm 8X	7.17 a	Sum 4X	13.17 ab	Emb 1X	17.57 a	Sum 1X	26.67 ab	Sum 4X	27.94 ab
Pac 2X	6.67 a	Cut 1X	11.67 ab	Cut 1X	16.09 a	Pac 2X	23.71 ab	Pac 2X	23.71 ab
Pac 1X	6.33 a	Pac 4X	10.33 ab	Pac 2X	13.55 a	Pac 4X	20.74 ab	Pac 4X	21.59 ab
Pac 4X	6.33 a	Pac 2X	10.00 ab	Cut 4X	12.70 a	Cut 1X	18.63 ab	Cut 1X	18.63 ab
Cut 2X	6.33 a	Cut 2X	7.67 b	Pac 4X	11.28 a	Cut 2X	17.78 ab	Cut 2X	18.63 ab
Cut 4X	6.00 a	Cut 4X	7.67 b	Cut 2X	10.16 a	Cut 4X	12.70 b	Cut 4X	13.12 b

Table A.22: Mean heights (cm) by date of *Wedelia trilobata* treated with growth regulators one day after mowing on July 19, 1994 at Kapolei Golf Course.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Wedelia trilobata

9/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	33.87	2.26	0.47	ns	ns
Rep	2	6.12	3.06	0.64	ns	ns
Error	30	143.35	4.78			
TOTAL	47	183.33				

10/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	1106.89	73.79	6.15	*	**
Rep	2	70.72	35.36	2.95	ns	ns
Error	30	360.15	12.00			
TOTAL	47	1537.76				

10/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	1903.99	126.93	2.86	*	**
Rep	2	102.08	51.04	1.15	ns	ns
Error	30	1333.40	44.45			
TOTAL	47	3339.48				

11/11/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	2893.92	192.93	3.39	*	**
Rep	2	209.54	104.77	1.84	ns	ns
Error	30	1709.48	56.98			
TOTAL	47	4812.95				

2/1/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	1079.80	71.99	2.92	*	**
Rep	2	122.65	61.32	2.49	ns	ns
Error	30	738.64	24.62			
TOTAL	47	1941.09				

Table A.23: Analysis of variance for the effects of growth regulators applied three weeks after trimming on height of *Wedelia trilobata* . Field study no. 2 (Chap. III)

9/28/94		10/14/94		10/28/94		11/11/94		2/1/95	
Pac 2X	9.74 a[z]	Emb 1X	26.67 a	Prm 2X	33.87 a	Prm 2X	38.10 a	Sum 4X	25.40 a
Emb 4X	9.53 a	Control	25.40 ab	Emb 1X	33.02 a	Control	37.25 a	Prm 4X	24.55 a
Control	8.89 a	Emb 4X	25.40 ab	Pac 2X	33.02 a	Pac 2X	37.25 a	Emb 1X	22.86 a
Pac 1X	8.47 a	Pac 2X	24.13 ab	Control	31.33 ab	Pac 1X	33.02 ab	Emb 2X	22.86 a
Prm 2X	8.47 a	Emb 2X	24.13 ab	Emb 4X	33.02 ab	Emb 4X	33.02 ab	Prm 8X	21.17 ab
Sum 1X	8.04 a	Prm 2X	22.01 ab	Pac 1X	29.63 ab	Prm 8X	31.29 ab	Prm 2X	19.47 ab
Emb 2X	8.04 a	Pac 1X	21.49 ab	Sum 1X	27.94 ab	Prm 4X	30.59 ab	Emb 4X	18.63 ab
Pac 4X	7.62 a	Pac 4X	20.32 abc	Sum 2X	27.94 ab	Sum 1X	30.48 ab	Sum 2X	18.20 ab
Sum 2X	7.62 a	Sum 1X	19.47 abc	Pac 4X	27.09 ab	Sum 2X	29.63 ab	Control	17.78 ab
Prm 4X	7.62 a	Sum 2X	19.47 abc	Prm 4X	27.09 ab	Emb 1X	26.25 ab	Pac 1X	17.78 ab
Cut 4X	7.62 a	Prm 4X	18.63 abc	Prm 8X	27.09 ab	Emb 2X	26.25 ab	Pac 4X	17.78 ab
Emb 1X	7.20 a	Sum 4X	17.36 abc	Emb 2X	24.55 ab	Sum 4X	24.55 ab	Sum 1X	17.78 ab
Cut 1X	7.20 a	Prm 8X	15.66 bc	Sum 4X	22.01 ab	Pac 4X	24.13 ab	Cut 1X	16.09 ab
Sum 4X	6.77 a	Cut 1X	15.24 bc	Cut 1X	17.78 ab	Cut 1X	18.63 ab	Pac 2X	15.66 ab
Prm 8X	6.77 a	Cut 2X	10.58 c	Cut 2X	13.97 ab	Cut 2X	16.09 ab	Cut 2X	13.55 ab
Cut 2X	5.72 a	Cut 4X	10.68 c	Cut 4X	12.70 b	Cut 4X	12.70 b	Cut 4X	6.35 b

Table A.24: Mean heights (cm) by date of *Wedelia trilobata* treated with growth regulators three weeks after mowing on September 7, 1994 at Kapolei Golf Course.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

Wedelia trilobata

10/14/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	496.98	33.13	2.44	*	ns
Rep	2	74.06	37.03	2.72	ns	ns
Error	30	407.87	13.60			
TOTAL	47	978.90				

10/28/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	1049.43	69.96	3.59	*	**
Rep	2	44.96	22.48	1.15	ns	ns
Error	30	585.15	19.50			
TOTAL	47	1679.53				

11/11/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	1538.67	102.58	5.88	*	**
Rep	2	49.80	24.90	1.43	ns	ns
Error	30	523.32	17.44			
TOTAL	47	2111.79				

12/23/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	21.47	1.43	0.92	ns	ns
Rep	2	1.81	0.91	0.58	ns	ns
Error	30	46.57	1.55			
TOTAL	47	69.86				

2/1/1994

SOURCE	df	SS	MS	F	F .05	F .01
Treatment	15	859.37	57.29	5.67	*	**
Rep	2	20.63	10.32	1.02	ns	ns
Error	30	303.02	10.10			
TOTAL	47	1183.03				

Table A.25: Analysis of variance for the effects of growth regulators applied five weeks after trimming on height of *Wedelia trilobata* .
Field study no. 2 (Chap. III)

10/14/94		10/28/94		11/11/94		12/23/94		2/1/95	
Emb 4X	20.32 a[z]	Control	26.25 a	Control	31.33 a	Emb 4X	7.62 a	Control	21.17 a
Pac 1X	19.47 a	Pac 1X	25.40 a	Emb 4X	30.48 a	Sum 1X	7.20 a	Pac 4X	19.90 ab
Emb 2X	19.05 a	Emb 1X	25.40 a	Pac 1X	28.79 a	Pac 2X	6.77 a	Pac 1X	18.63 abc
Pac 2X	18.63 a	Emb 4X	25.40 a	Emb 2X	27.94 a	Pac 4X	6.35 a	Sum 1X	18.63 abc
Control	16.93 a	Sum 1X	24.55 a	Pac 2X	26.25 ab	Sum 4X	6.35 a	Prm 2X	16.93 abcd
Prm 2X	16.93 a	Emb 2X	24.13 a	Sum 2X	26.25 ab	Cut 2X	6.35 a	Sum 2X	16.09 abcd
Sum 1X	16.09 a	Pac 2X	23.71 a	Prm 2X	26.25 ab	Prm 8X	6.35 a	Pac 2X	15.24 abcde
Emb 1X	16.09 a	Prm 2X	23.71 a	Prm 4X	26.25 ab	Control	5.93 a	Emb 4X	15.24 abcde
Pac 4X	15.24 a	Sum 2X	22.86 ab	Sum 1X	25.40 ab	Cut 1X	5.93 a	Prm 4X	15.24 abcde
Sum 2X	15.24 a	Prm 4X	21.59 ab	Emb 1X	25.40 ab	Emb 2X	5.93 a	Prm 8X	14.39 abcde
Prm 4X	15.24 a	Sum 4X	21.17 ab	Prm 8X	23.71 abc	Prm 2X	5.93 a	Sum 4X	12.70 abcde
Sum 4X	14.73 a	Pac 4X	20.32 ab	Pac 4X	22.86 abc	Prm 4X	5.93 a	Emb 1X	11.01 bcde
Cut 1X	11.01 a	Prm 8X	19.47 ab	Sum 4X	21.17 abc	Pac 1X	5.50 a	Emb 2X	10.16 cde
Cut 2X	11.01 a	Cut 2X	13.97 ab	Cut 1X	14.82 bc	Sum 2X	5.50 a	Cut 1X	9.31 cde
Prm 8X	11.01 a	Cut 1X	13.55 ab	Cut 2X	14.39 bc	Cut 4X	5.08 a	Cut 2X	8.04 de
Cut 4X	9.31 a	Cut 4X	10.16 b	Cut 4X	11.01 c	Emb 1X	5.08 a	Cut 4X	6.35 e

Table A.26: Mean heights (cm) by date of *Wedelia trilobata* treated with growth regulators five weeks after mowing on September 28, 1994at Kapolei Golf Course.

[z]Mean separation by Tukey HSD (5% level). Means in columns followed by the same letter are not significantly different.

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